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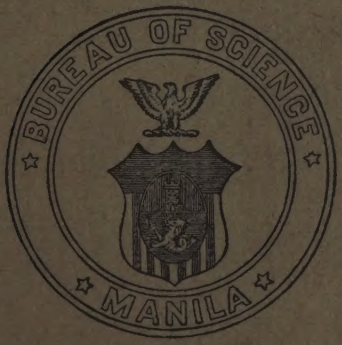

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THE PHYSIOLOGICALLY ACTIVE CONSTITUENTS OF CERTAIN PHILIPPINE MEDICINAL PLANTS.

By RAYMOND FOSS BACON.
(From the Chemical Laboratory, Bureau of Science.)

INTRODUCTION.

The number of native plants used for medicinal purposes by the Filipinos is very great. Among this multitude of remedies it is desirable to know which ones are really valuable and which ones are worthless, and it is also important to isolate and study their active constituents, as such work may reveal substances valuable in pharmacology which hitherto have been unknown. It is also true that many plants are found in the Philippines which are closely allied botanically to well-known species which in other countries produce physiologically active substances, but the natures of which are as yet unknown to the native.

With such a vast field to choose from, it was considered advisable to adopt the following plan: A preliminary examination is being made as rapidly as possible of such plants as are reputed by the natives to have medicinal value, or of such as are known to be used in other countries. These preliminary experiments have included both chemical and physiological tests. In cases where a physiologically active substance can be isolated in a pure condition, and especially where large yield, accessibility, and easy separation render feasible the acquisition of quantities of these active chemical compounds, it is proposed to make detailed studies. It is expected that these investigations will include not only chemical work but also thorough physiological and practical medicinal tests, when these seem to be warranted.

In performing much of the physiological work, I have had the coöperation of Dr. R. P. Strong, chief of the Biological Laboratory, and of Drs. Marshall and Edwards, of the Biological Laboratory, to whom I desire to express my thanks for indispensible assistance. Mr. E. D. Merrill, botanist of this Bureau, has made the identifications of the plants studied, and has assisted in collecting them, and to him, also, my thanks are due.

In choosing the plants for the work in hand, I have made free use of Dr. Tavera's book [1] "Medicinal Plants of the Philippines." I have also talked with both educated and uneducated natives and with many native doctors, in order to ascertain what plants are commonly used in practice and have consulted European physicians who have practiced in the Philippines for many years.

I have been told of plants with marvelous properties, which quickly effect wonderful cures of diseases such as are usually believed to be incurable. Educated physicians practicing in the Islands tell me that such rumors are common, but that they have never seen the cures or been able to repeat the uneducated physician's results by using his infallible remedy, although they have had opportunities to study the native healer at close range. Thus, many cases of sarcoma were cited where the primitive doctor told of wonderful cures with his plants from the forest, and promised great things, but either would not or could not accomplish anything before the well-informed practitioner. It is difficult to obtain data as to the nature of a medicinal plant not only because of the very inaccurate observations on the part of the natives but also because of a very prevalent habit of concocting a medicine with many drugs, which renders the study infinitely complicated. The theory is that if one drug is good, a great many are better. I have had occasion to analyze medicines in this laboratory which were ascertained to contain no less than thirty substances which are known to be physiologically active.

With such a confused state of knowledge in such a large field, it was considered advisable to make a preliminary examination of many drugs, to be followed later by a more detailed examination of such as seemed to warrant it.

Other plants which contain interesting substances, such as arrow poisons, fish poisons, dyestuffs, etc., have been included in the scope of the work. The results thus far obtained are recorded below.

The Bark of ALSTONIA SCHOLARIS R. Br.[2] (*Apocynaceæ*).

The large tree, *Alstonia scholaris*, is found in tropical Asia, Malaya, and northern Australia. It is widely distributed and very abundant in the Philippines. The native name of the plant is "*dita*," or "*ditaä*." Dita bark is regarded all over the Islands to be a remedy for fevers and

[1] Translated by J. B. Thomas (1901).

[2] *Mem. Wern. Soc.*, **1**, 75; Hook f. Fl. Brit. Ind., **3**, 642.

for chronic diarrhœa and dysentery. I should class it as the most widely known and most important Filipino drug. If a native knows of but one kind of medicinal plant, that one is invariably "*dita*." In India, the tree is also well known as an astringent tonic, anthelmintic, alterative, and antiperiodic. "It is a valuable remedy in chronic diarrhœa and dysentery." [3] In the Philippines, *dita* is considered to be a febrifuge of great importance. As a tonic it is said to give as good results as quinine. Its action has been compared to quinine, and, in fact, I was assured by white physicians that the bark contained quinine, which statement is of course erroneous. The native method of preparing the bark for medicinal uses is as follows:

About 15 grams of the powdered bark (one handful) is boiled with about 400 cubic centimeters of water until half the water has boiled away. The solution is then strained and made up to the original volume. The dose of this decoction is 30 to 60 cubic centimeters three or four times a day. This dose is equivalent to about 2 to 4 milligrams of echitamine. Tavera [4] recommends a wine prepared by macerating one bottle of muscadel or sherry with 25 grams of the bark. Dose one-half wineglass before meals. A tincture of the bark has also been prepared,[5] for which the dose calculated to the bark is very much smaller. As the active constitutents of the plant are exceedingly soluble in water, the lessening of the dose in the tincture is material.

There seems to be a very widespread opinion, even among educated physicians, that the *dita* bark extract is an excellent tonic during convalescence from exhausting diseases.

PREVIOUS LITERATURE ON THE ALKALOIDS FROM DITA BARK.

The fame of *dita* as a healing agent dates from great antiquity (Rheeder [1678] and Rhumpius [1741]), but in more modern times attention was again called to the bark by Gruppe, a pharmacist in Manila, who in 1883 prepared from it a bitter substance which he called "ditaïn." Gruppe used the same process to obtain this substance as that employed in the preparation of quinine, and he thus obtained from 100 parts of bark, 2 parts of his ditaïn in addition to 10 parts of inactive substances and 0.85 parts of gypsum. This ditaïn, according to Dr. Pina, then chief physician of the Province of Manila, possessed the antipyretic properties of the bark to a high degree. A report [6] at that time stated:

The results arrived at in the Manila hospitals and in private practice are described as simply marvelous; if further adds "that in military hospitals and in penitentiary practice (Manila) ditaïn has perfectly superseded quinine, and is now being employed with most satisfactory results in the Island of Mindanao, where the malignant fevers are prevalent."

[3] Watts: Dict. Econ. Plants of India (1885), 1, 198.
[4] *Ibid.* (1901), 164.
[5] National Standard Dispensatory (Hare) (1905), 139.
[6] Watts: Dict. Econ. Plants of India (1885), 1, 199.

The identity of Gruppe's ditaïn is very doubtful. Tavera states that the dose of it is the same as that of quinine; hence it could not have been echitamine, the principal alkaloid of *dita,* as this substance in comparison with quinine is exceedingly poisonous.

As to the important medical results obtained, I was informed, by a European physician who was stationed in Manila at the time of Dr. Pina's tests, that the testimony of cures, etc., was made in reply to a request for quinine from the provinces where malaria was raging in epidemic form. Quinine was considered too expensive, so that the rural inhabitants were given ditaïn, while at the same time a statement as to its efficiency in place of quinine was made. The above statement gains in probability in view of the physiological behavior of dita, which I have found to be not at all like that of quinine.

Later, more important researches on *dita* bark were made by Jobst and Hesse[7] and by Harnack.[8] Harnack claimed that there is but one alkaloid in *dita* bark, which alkaloid he called ditaïn, and which is not to be confused with the impure product of Gruppe. He claimed that ditaïn is really a glucoside because, after boiling with hydrochloric acid, it reduces Fehling's solution. Hesse found several alkaloids in the bark which he studied, namely, ditamine, echitamine, echitenine, and oxyechitamine. Of these echitamine was found to be present in largest amounts and was the most thoroughly studied. A number of salts were prepared and analyzed, the formula $C_{22}H_{28}N_2O_4 + H_2O$ being established. Harnack[9] replied to the work of Hesse and reasserted his claim that there is but one alkaloid in *dita* bark; and he maintained that his ditaïn was identical with the ditamine of Hesse. Gorup-Besanez[10] examined Gruppe's ditaïn chemically and succeeded in obtaining from it a small amount of a crystalline substance which was apparently an alkaloid, but the amount of the latter which he isolated was too small to admit of any further examination.

As the bark is quite easily accessible in the Philippines, I have obtained and am investigating a large quantity. It is of a yellowish-brown color and from 1 to 12 millimeters thick. The outer layer has a scaly appearance because of its longitudinal and transverse fissures and is not infrequently marked with small, black spots. The bark breaks with rather a brittle fracture and this makes it easy to powder when dry; it is odorless and of a bitter taste which varies greatly in different samples. Some lots are exceedingly bitter, but with others this taste does not develop until the bark has been chewed for some time. The outer bark is always much more bitter than the inner, corky layer; in fact many pieces of the latter are tasteless. The wood of the tree and the bark of young twigs are not bitter and contain no alkaloid.

In the air dry bark I found 15.2 per cent of moisture (determined at 105°) and 3.29, 3.14, and 2.67 per cent, respectively, of ash in three

[7] *Ann. Chem.* (*Liebig*) (1875), **178,** 49; *Ibid* (1880), **203,** 144; *Ber. d. chem. Ges.* (1880), **13,** 1648.

[8] *Arch. f. Exp. Path. u. Pharmakol.* (1887), **7,** 126.

[9] *Ber. d. chem. Ges.* (1878), **11,** 2004.

[10] *Ann. Chem.* (*Liebig*) (1887), **176,** 88.

samples. With water the bark gives a very bitter, brown extract, which remains clear on standing and which is not affected by iron salts. Lead acetate gives a yellowish-white, flocculent precipitate in the aqueous solution; basic lead acetate, added to the filtrate, gives a further precipitate, but neither of these substances throws down the alkaloid. After removing the excess of lead salts, the latter is to be found in the filtrate. This is contrary to the observation of Hildewein,[11] according to whom lead acetate precipitates the bitter substance.

On extraction with alcohol the bark yields a very large amount of a gummy solid much of which is physically similar to gutta-percha, so that it is almost impossible to hope to separate the alkaloids from the alcoholic extract. Ether takes only indifferent substances from the bark, which separate out as a brownish, gummy mass. Petroleum ether extracts a large quantity of resins and gutta-percha-like bodies and, by shaking out the petroleum ether extract from large amounts of bark with dilute acids, one obtains only exceedingly small amounts of an alkaloid which seems to be ditamine. Some of the resins which are extracted by petroleum ether can be crystallized from alcohol or acetone and Hesse[12] has described several, namely: Echitin, echereïn, echiteïn, echiretin, ekikautschin. I have obtained fine, white, crystalline resins in large amounts which corresponded to some of these, but as tests on animals showed them to be physiologically inactive, I have not deemed it worth while to follow the subject further. They all appear to be oxidized terpenes, the formula of all of them being resoluble into $(C_5H_8)_xO_y$. Chloroform extracts no alkaloid from the bark, while Prollius's mixture takes up a highly elastic, white gum which only contains a very small amount of alkaloid.

Very dilute hydrochloric acid extracts all of the alkaloid, and it is this solvent which Gruppe used to obtain his ditaïn. On neutralizing with ammonia, a brownish precipitate is formed which corresponds to his ditaïn, but which in my experience contains no alkaloid, or at best only traces.[13] Hesse made this same observation and concluded that the substance thus obtained is principally calcium oxalate. His bark showed 10.4 per cent ash, principally chalk, as against 3.3 per cent for my highest figure.

METHODS OF SEPARATION OF THE DITA ALKALOIDS.

To obtain the *dita* alkaloids in quantity I have used two methods:

(*a*) The first follows very closely that used by Hesse. The finely ground bark is extracted hot with petroleum ether by aid of a reflux condenser. The solvent is then distilled to a small volume and shaken out with dilute acids, the latter made alkaline with ammonia, etc. In this way 0.1 to 0.2 gram of ditamine is

[11] *Pharm. Centralhalle f. Deutschland* (1873), **26.**

[12] *Loc. cit.*

[13] Seven experiments on five different lots of bark.

usually obtained from 5 kilos of bark. The bark is now extracted hot, until exhausted, with 85 per cent alcohol, to which a little dilute sulphuric acid has been added. The alcohol is then distilled and to the aqueous, acid residue, which is usually of the consistency of molasses, double the volume of water is added. This solution is left standing in a cold place for a few days, after which it is centrifuged to separate as much of the gum as possible, for, in order to obtain a good yield of the *dita* alkaloids, it is necessary to get rid of the gummy substances in some way, as otherwise the alkaloids seem to be held in solution so that they can not be shaken out with immiscible solvents.

The aqueous solution is now gently evaporated *in vacuo* to an appropriate volume, made alkaline with sodium carbonate and shaken out with ether as long as this solvent removes anything. Upon evaporation, a small amount of ditamine is obtained, usually 0.3 gram from 5 kilos of bark. The aqueous solution is now rendered very strongly alkaline with sodium hydrate and shaken out several times with chloroform; it is usually found necessary to centrifuge the emulsions obtained in this way. The chloroform is now distilled off and the residue is dissolved in hot, 1 per cent hydrochloric acid and the solution evaporated to a small volume. Concentrated hydrochloric acid, or a soluble chloride, is now added in considerable quantity, whereupon echitamine hydrochloride separates in needle-like crystals, which at this stage are usually somewhat brown. The hydrochloride of the alkaloid is now recrystallized from water, two recrystallizations usually being sufficient to render it pure, the yield from 5 kilos of bark being 5 to 7 grams.

As it will be necessary to work up several hundred pounds of *dita* bark to obtain a sufficient quantity of alkaloid for a more extensive study, I have considered it necessary to develop a simpler and cheaper method of obtaining the alkaloid. These experiments have occupied much time. It was soon shown that the alkaloid can be completely extracted with dilute acids, but precipitation of the solutions thus obtained, according to the methods of Mayer or of Kippenberg, or with phospho-molybdic acid, gave no satisfactory results, hence the following method was finally adopted:

(*b*) The finely powdered bark is percolated in one-half per cent acetic acid until exhausted; this solution is then evaporated *in vacuo* to a small volume, preliminary experiments showing that such treatment does not cause any loss or decomposition of the alkaloid; this solution is then continuously boiled with a little animal charcoal to remove some of the gum and is then centrifuged. Care must be exercised because too much animal charcoal takes up alkaloid as well as gum. This process gives a fairly clean solution, which is made alkaline, shaken out with solvents, and treated further as in method (*a*). The yield is the same.

The following tests on guinea pigs show that practically all the physiologically active constituents are obtained from the bark by this treatment. One kilo of bark, which had been found to contain 0.135 per cent of alkaloid, was treated according to method (*b*) and the dilute acid solution evaporated *in vacuo* to 135 cubic centimeters. Five cubic centimeters of this crude solution were taken for physiological tests, and from the remaining 130 cubic centimeters, 1.3 grams of echitamine hydrochloride were obtained. The physiological tests resulted as follows:

Experiment A.—Guinea pig of 210 grams: 1 cubic centimeter of crude extract, containing 0.01 gram of alkaloid, injected intraperitoneally. After four minutes the animal begins to tremble and apparently to lose control of the muscles supporting the head; after seven minutes it lies down, unable to move, after which several spasmodic respiratory movements follow. Dead in fifteen minutes.

Experiment B.—Guinea pig of 195 grams: 0.5 cubic centimeter of crude extract, containing 0.005 gram of alkaloid, given intraperitoneally; all the usual symptoms of asphyxiation follow, but the animal lives for forty-eight hours.

The physiological tests on pure echitamine hydrochloride which are reported below, show that the minimum fatal dose for a guinea pig of about 200 grams is 5 milligrams and that 0.01 gram kills an animal of this size in about sixteen minutes, the symptoms being exactly the same as those observed with the crude extract. Hence, I consider that Experiments A and B prove that practically all the physiologically active constituent of the bark has been extracted, and that this substance is the alkaloid echitamine.

THE ALKALOIDS OBTAINED FROM DITA BARK.

Ditamine.—Hesse [14] has given this name to the alkaloid which can be obtained by rendering the aqueous solution from the plant alkaline with sodium carbonate, and then shaking out with ether. The alkaloid is removed from the solvent by means of dilute acetic acid, which is then rendered alkaline with ammonia and the resulting solution extracted with ether. Hesse states the yield of this alkaloid to be 0.02 to 0.04 per cent, but from 10 kilos of the bark he obtained only 0.4 gram of ditamine; the other nine tenths of the alkaloid he believes to have been occluded by one of the resins. I have succeeded in obtaining only very small amounts of ditamine, the largest yield being 0.3 gram of alkaloid from 5 kilos of bark. I have not been able to separate ditamine from any of the resins. These facts, together with my physiological experiments on the crude extracts from the plant, and Harnack's repeated claims that the dita bark contains but one alkaloid, make it doubtful whether the bark contains the percentage of ditamine claimed by Hesse.

As deposited from ether, ditamine is a varnish-like substance, slightly yellowish in color. It is easily soluble in ether, benzene, chloroform, and alcohol. From all these solvents it separates in an amorphous condition. It is not very soluble in petroleum ether. Some ditamine was dissolved in a small volume of chloroform and to this three volumes of petroleum ether was added. The ditamine separates at once in flocks, but is not obtained in a crystalline form by this procedure. Solutions of ditamine in the solvents mentioned above were very slowly allowed to evaporate for some weeks in the cold storage, but no crystals were obtained.

Concentrated sulphuric acid dissolves ditamine, giving a red color, which on warming becomes more violet, but the color is not nearly as strong as in the similar test with echitamine. With concentrated nitric acid a blue, then a green color is

[14] *Loc. cit.*

obtained which rapidly changes to orange-red. Ditamine with Froehdes's reagent gives a fine, indigo-blue color, which rapidly passes into a green. With concentrated sulphuric acid, to which a little cane sugar has been added, the alkaloid gives a red color; however, this reaction is not sensitive; the color could not be distinguished from that obtained with concentrated sulphuric acid alone.

The taste of the free alkaloid is pleasantly bitter, that of the salts exceedingly so. The alcoholic solution turns red litmus paper to a blue color, and the alkaloid is freely soluble in acidulated water; when such a solution is rendered alkaline, ditamine separates in white flocks. The alkaloid has an odor which reminds one very much of dimethyl aniline; this is especially true if it is freshly prepared and damp or if it still contains a little alkali. The odor is probably due to a slight decomposition, and it is of interest in view of the fact that Harnack [15] claimed that his detaïn was decomposed by boiling with concentrated hydrochloric acid into glucose and the hydrochloride of an oil which he suspected to be dimethyl aniline. Hesse prepared the hydrochloride of this alkaloid, but was not able to study it because of scanty material. The solution of ditamine hydrochloride gives precipitates with phospho-molybdic acid, with iodine-potassium iodide solution, and with tannin; it is not changed by ferric chloride. A small amount, heated in a test tube with solid, powdered potassium hydrate, gave the dimethyl aniline odor referred to above.

I have not been able to obtain a sufficient amount of ditamine for detailed study from the material thus far worked up. In the future work an exhaustive attempt will be made to settle the question as to the amount of this alkaloid present in *dita* bark.

Echitamine.—Echitamine or, as Hesse prefers to call it, echitammonium hydroxide, is obtained as a brown, varnish-like mass on evaporating the chloroform solution obtained by shaking out the strongly alkaline solution, as was mentioned in the method of preparation outlined above. The hydrochloride can readily be isolated from the crude alkaloid thus obtained, and from this salt it is easy to separate the free alkaloid. To this end the salt is dissolved in water, the solution rendered strongly alkaline with sodium hydrate and then shaken out with chloroform. If the chloroform is allowed slowly to evaporate in the cold storage, crystals of the free alkaloid are obtained in the form of prisms, but if the solvent is evaporated rapidly, echitamine usually separates in an amorphous condition. It is also possible to obtain the alkaloid crystalline from its solution in strong alcohol or in equal parts of water and acetone.

The free base is rather easily soluble in water; this aqueous solution turns litmus paper blue and has an exceedingly bitter taste. The alkaloid dissolves in both hot and cold alcohol; it is insoluble in cold acetone, but more soluble in hot. It is freely taken up by chloroform, but only with difficulty by petroleum ether. Freshly precipitated echitamine dissolves in ether, but the crystals are insoluble in this medium.

[15] *Loc. cit.*

Concentrated nitric acid dissolves echitamine to give an intense, red color which, in the course of a minute passes through yellow into a brillant green, which persists. Evaporation of the nitric acid leaves an intense green, microcrystalline residue, which dissolves easily in water to a yellow solution. A drop of nitric acid again turns this solution green. Concentrated sulphuric acid gives a red color, which becomes more purple on standing. Heating brings out the color more intensely. Addition of water to the acid destroys the color. These color tests for echitamine with concentrated nitric and sulphuric acids can readily be obtained from a fragment of the *dita* bark, which can thus be identified. With Froehde's reagent, echitamine instantly gives a most intense crimson, which gradually passes into green. Concentrated sulphuric acid, to which a little cane sugar has been added, at once developes a brilliant, persistent crimson; both of these last color reactions are much stronger than they are with sulphuric acid alone (a difference from ditamine).

Echitamine is a monoacid base which can be quantitatively titrated with acids, using methyl orange as an indicator.

Hesse assigns the formula $C_{22}H_{28}N_2O_4$ to this base, whereas Harnack obtained figures agreeing for $C_{22}H_{30}N_2O_4$. As it is very difficult to decide these formulæ by analysis, I have decided to leave this question for settlement when a study of the derivatives of this alkaloid is undertaken.

The air dry alkaloid contains four molecules of water.

0.5149 gram echitamine heated to 105°–110° *in vacuo* lost 0.0803 gram water.

Required for $C_{22}H_{28}N_2O_4$, 4 H_2O		Found
	Per cent.	Per cent.
4 H_2O	15.76	15.51

By drying *in vacuo* at 75° three molecules of water only are lost.

0.2416 gram alkaloid gave a loss of 0.0293 gram H_2O at 75°.

Required for 3 H_2O	Found
Per cent.	Per cent.
11.84	12.1

Hesse obtained results similar to mine, and from them he concluded that the alkaloid was really echitammonium hydroxide, the last molecule of water being one of constitution. He was further led to this view by the fact that the alkaloid behaves as a fairly strong base. Not only is its aqueous solution strongly basic to test papers, but it readily precipitates copper, iron, and aluminum salts without redissolving the precipitates when in excess. The alkaloid liberates ammonia from a solution of ammonium chloride and sets free the alkaline hydroxide from sodium or calcium chloride, echitammonium chloride separating in crystals. Hesse considered echitammonium hydroxide to be the most pronouncedly basic of all the alkaloids.

I have tested this assumption, using the conductivity method, and have obtained the following results:

μ_v = molecular conductivity at dilution v,
v = number of liters in which one gram molecule of substance is dissolved.
C = constant of the conductivity cell used.
ω = resistance in ohms of the rheostat.
a and b = the lengths in millimeters on the measuring arm of the Wheatstone bridge.
$\alpha = \frac{\mu_v}{\mu \infty}$, whence 100α = dissociation expressed in per cent.
k = affinity constant of the base $= \frac{\alpha^2}{v(1-\alpha)}$ for a weak base.

The calculations are based on the usual formula: $\mu_v = \frac{va}{\omega b} C$. All measurements were made at 25°.

Echitamine hydrochloride.

v	μ_v
42	84.5
168	85.5
420	87.5

Echitammonium hydroxide.

v	μ_v	100α	k
35	57.7	27.6	.0030
140	58.7	28	.00077
350	65.5	31.3	.00036
∞	209		

If echitammonium chloride is assumed to be completely dissociated at the dilution v=420, the molecular conductivity of the chlorine ion is taken as 75 for that dilution, and the molecular conductivity of the hydroxyl ion at dilution ∞ is taken as 196, then 13 results as the molecular conductivity of the echitammonium ion and 209 as the molecular conductivity of echitammonium hydroxide at infinite dilution. From these results it is seen that it is too strong a base for its affinity constant to be calculated by the dilution formula given above, which is accurate only for weak bases and acids, but, as it is dissociated in a 1 per cent solution to the extent of about 28 per cent, it is moderately strong.

For purposes of comparison I add the figures obtained by Bredig[16] on coniïne and piperidine, and also measurements made by myself on atropine.

[16] *Ztschr. f. physik. Chem.* (1894), **13**, 289.

Piperidine.			Coniïne.			Atropine hydrochloride.		Atropine.		
v	μ_v	100α	v	μ_v	100α	v	μ_v	v	μ_v	100α
8	21.5	10.6	16	26.4	13.5	32	125.2	87	22.3	8.4
16	30.2	14.9	32	36.4	18.7	128	132.5	174	33.8	12.8
32	41.3	20.3	64	49.6	25.4	320	142.6	∞	263.0	
64	55.3	27.2	128	65.4	33.5					
128	72.7	35.8	256	83.0	42.6					
256	93.2	45.9								

Echitamine, when rapidly heated, melts and at the same time decomposes at 200°–208°, depending upon the rapidity of the heating. Echitamine hydrochloride crystallizes in the form of brilliant needles, moderately soluble in cold water, more readily so in hot. Platinic chloride gives no precipitate in a 1 per cent solution of this salt; neither do concentrated hydrochloric acid or soluble chlorides precipitate it in this dilution. The addition of a little concentrated hydrochloric acid to a 20 per cent solution causes an instant precipitation of practically all of the salt of the alkaloid as a white, crystalline powder, while a little of the same acid added to a 5 per cent solution separates the alkaloidal salt more slowly in the form of beautiful bunches of crystalline needles. The products obtained by heating echitamine hydrochloride with hydrochloric acid reduce Fehling's solution, but the alkaloid itself will not do so. On the other hand neither ditamine, nor any substances which may be produced from it by boiling with hydrochloric acid, affect this reagent.

Echitamine hydrochloride gives a transitory pink color with sodium perchlorate and hydrochloric acid. The latter acid alone gradually turns all solutions of the alkaloid to a deep, purple color, especially on boiling. This purple solution reduces Fehling's solution, but the reducing substances can be completely precipitated from it by the addition of the usual alkaloidal reagents. Hence a sugar is not present among the substances separated and therefore echitamine is not a glucoside, as Harnack has claimed it to be.

One gram of echitamine hydrochloride was heated for two hours in a water bath with 20 cubic centimeters of concentrated hydrochloric acid. The intensely purple solution was now diluted with water and made alkaline with sodium hydrate. A flocculent, white precipitate separated, which was filtered and washed. No oil, such as Harnack describes, and which he suspected to be dimethyl aniline, was observed on addition of the alkali. The precipitate contains a new alkaloidal substance which has not yet been investigated because of lack of material.

Alkaline hydroxides precipitate the white, flocculent, free base from concentrated solutions of the alkaloidal hydrochloride but, owing to the solubility of the former in water, no such separation takes place from dilute ones. Hesse has prepared several salts of "echitammonium hydrate," and those which I have examined confirm his descriptions in all respects.

PHYSIOLOGICAL EXPERIMENTS WITH ECHITAMINE HYDROCHLORIDE.

Experiment A.—Guinea pig of 208 grams: 0.05 gram of pure echitamine hydrochloride dissolved in 1 cubic centimeter of water, injected intraperitoneally. In two minutes there is great uneasiness with spasmodic contractions of the muscles of the ears and eyelids, followed very rapidly by violent twitchings of muscles of the head, the animal apparently becoming rapidly very weak. Violent convulsive spasms soon follow, the marked characteristic being the difficulty in breathing. The final stages show the usual gasping for breath as in cases of death by asphyxia. Death takes place in seven minutes.

Experiment B.—Guinea pig of 320 grams received 2 cubic centimeters of a 1 per cent solution of echitamine hydrochloride (0.02 gram) intraperitoneally at 10 a. m. After shaving the abdomen and preparing for the injection, the animal was returned to its cage, and after a few minutes the respirations were counted. The respirations were also counted at intervals after injecting the poison. The results of the experiment are tabulated:

Time.	Respirations per minute.	Remarks.
Before injection	138	
After 3 minutes	111	Animal quiet; very slight, infrequent, spasmodic contractions of muscles of ears and eyelids.
After 6 minutes	115	
After 9 minutes	106	Twitchings are increasing in strength and frequency.
After 15 minutes	63	Twitchings generalized; stronger; prolonged expiration.
After 17 minutes		Animal crawling uneasily about cage.
After 18 minutes	48	Respirations shallow, largely abdominal.
After 21 minutes	30	Gasping expirations followed by prolonged interval.
After 24 minutes		Convulsions for a few seconds; death.

An autopsy exposing the abdominal and thoracic cavities after apparent death showed irregular, spasmodic contractions of both auricles and ventricles of the heart for over two hours after all respiration had ceased. Intestinal peristalsis was still active for one-half an hour after the cessation of respiration.

Experiment C.—Guinea pig of 230 grams: 0.01 gram of echitamine hydrochloride in 1 cubic centimeter of water, injected intraperitoneally. In six minutes the animal is very weak and trembling. It crawls with difficulty uneasily around the cage. There soon follows the stage of more profound intoxication characterized by repeated, brief, clonic spasms. The breathing toward the end is very shallow and is almost entirely performed by the accessory (abdominal) muscles. Dead in eighteen minutes.

An autopsy made immediately after apparent death shows the lungs to be greatly congested. The heart has dilated and shows abortive auricular beats. The intestines are found still to exhibit strong peristaltic movements. The exposed heart continues to contract irregularly for about three hours, showing that this alkaloid is not a "heart poison," as has been claimed by some writers.

Experiment D.—Guinea pig of 245 grams: 0.005 gram of pure echitamine hydrochloride in 1 cubic centimeter of water injected intraperitoneally. The same series of symptoms as occur in Experiment B are observed but none of the stages are as violent. However, they are much more prolonged. The animal continued to be ill for about forty-eight hours, but then completely recovered.

These experiments have been selected as being typical of the physiological action of the alkaloid from a long series which included twenty animals and exactly the same effects were observed in every case.

Very much smaller doses than those given above are sufficient seriously to interfere with the coördination of the muscles in a guinea pig, accompanied by a persistent desire to lie down.

Experiment E.—Guinea pig of 230 grams: A sewing needle, dipped twice into a strong extract of *dita* bark and successively dried over a flame is inserted into the side of the animal to a distance of about 3 millimeters and then withdrawn. The guinea pig runs for a short distance and then lies down. It soon becomes very weak and its power of locomotion is seriously interfered with. Similar results are obtained on repeating this experiment. A control treated with an unpoisoned needle was not affected.

The minimum fatal dose of echitamine hydrochloride for a guinea pig of about 200 grams is 0.005 gram or 0.025 gram per kilogram of body weight. This dose is fatal for some animals, whereas others have recovered.

Echitamine is not a poison for protoplasm. Amœbæ suspended in a 1 per cent solution of echitamine hydrochloride seem to thrive quite well, no decrease in their motions being observed during two hours; neither is such a poison found in the aqueous solution of the bark. The latter when concentrated until it contains one per cent of the alkaloid, has no effect on the motility of amoebae. The use by the natives of *dita* extract in place of quinine for malaria or for amoebic dysentery would therefore seem to be of doubtful value. More comprehensive physiological tests on this alkaloid are now being undertaken and will be reported later, together with the further chemical study.

Hesse also mentions two other alkaloids, oxyechitamine and echitenine, but these were obviously not pure. A number of experiments on a substance corresponding in properties to his echitenine, have been made by me, but as I have not been able to obtain the pure alkaloid, I will reserve the publication of these data until a later paper.

DATURA FASTUOSA Linn.[17] (*Solanaceæ*).

Datura alba is distributed over tropical Asia, Africa, America, and Malaya. It is common about towns in the Philippines. The natives' names for the plant are *talamponai, catchibong,* and *catchubung.* In all parts of the East this plant is considered to be poisonous and it is used quite commonly with criminal intent in India and Indo-China. In China it is often mixed with tea or a tea is prepared from the leaves which is said to taste deceptively like the genuine article, so that it can be used as a poison without exciting suspicion in the victim. The early symptoms of *datura* poisoning are dilatation of the pupil, drowsiness and

[17] D. fastuosa Linn. var. alba Clarke, in Hook. f. Fl. Brit. Ind. (1883), 4. Linn., Syst. ed. X, 932.

general weakness, often accompanied by hallucination. With medium doses there is recovery in twelve to twenty-four hours, but there is usually a loss of memory and great confusion of ideas for many days afterwards. It is this effect which gives rise to the use of the drug by the Chinese for stupefying a victim whom they intend to rob.

The poisoning of enemies is not a very frequent practice among the Filipinos, but toxicological work has come to this laboratory, during the prosecution of which hyoscin was found in the stomach of the victim, it being very easily extracted because of its great solubility in ether. The dry leaf of the plant is smoked by the natives to stop asthma and is said to be very effective in many cases.

Datura alba contains hyoscin, hyoscyamin, and atropine, the first named amounting to over 90 per cent of the total alkaloids present. Hesse,[18] who obtained his material from eastern sources, has made a detailed investigation of this plant, and as there has been so much controversy on the alkaloids hyoscin and scopolin, I have considered it desirable to make a further study of *Datura alba*. In the air-dried leaves from Philippine specimens of the plant, I found 0.21 per cent of total alkaloids, in the seeds 0.465 per cent, and in the wood and roots (ground up together) 0.17 per cent. I can confirm Hesse's statements as to the properties of hyoscin in every particular.

The plant is a common weed in the Islands and might readily be used as a source of hyoscin, as two or three crops a year could easily be obtained. I expect to work out a cheap method of isolating the alkaloids from this plant with the hope of starting a small industry. Chemical studies of oscine, the decomposition product from hyoscin, are also under way.

CAESALPINIA SAPPAN Linn.[19] (*Leguminoseæ*).

This tree is encountered from British India to Malaya; it is also common and widely distributed in the Philippines. The Tagalog name is *sibucao,* or *sapang. Sibucao* is chiefly used as a dyewood, it being known in the English markets as sappan wood, and it is very popular among the Filipinos for dyeing the native fabrics. A decoction of the wood is also used in medicine, it being administered in cases of hæmorrhage, especially those from the lungs, the red color probably suggesting its use to check bleeding. The decoction has also been employed in cases of chronic diarrhœa, in which instances its efficiency is probably due to the tannin which it contains.

In some reference books the statement is made that sappan wood contains brasilin and, indeed, Bolley[20] identified this alkaloid in the coloring matter obtained from the wood. In view of its economic

[18] *Ann. Chem.* (*Liebig*) (1898), **303**, 149.
[19] Sp. Pl. (1753), 381; Baker in Hook. f. Fl. Brit. Ind., **2**, 254.
[20] *J. Prakt. Chem.*, **93**, 351.

importance in these Islands and because of inquiries made at this Bureau and at the Bureau of Forestry, it was considered advisable to confirm these statements.

As the roots are said to contain the greater percentage of coloring matter, 1 kilo of these were finely ground and then heated in a closed vessel, with water, for eight hours. The aqueous extract was filtered from the wood and evaporated *in vacuo* to a small bulk, whereupon an aliquot portion was desiccated, giving a residue of 2.7 per cent. The concentrated liquor was placed in the cold storage for two weeks, when a reddish, crystalline crust had been deposited. This was dissolved in 12 per cent alcohol containing a little hydrochloric acid and zinc, filtered, evaporated and the brasilin recrystallized from strong alcohol.

The brasilin thus obtained was in amber-colored crystals, soluble in water, alcohol, and ether. With ammonia it gave an intense carmine, as it did with potassium or barium hydrates. The solution in sodium hydrate, when decolorized with zinc dust, rapidly absorbed oxygen from the air and again became colored. With aluminum sulphate or with ferric chloride it gave purple, black lakes. Brasileïn was obtained as a brown, crystalline powder upon oxidation with nitric acid. The alkaline solution of brasilin, which had been turned red by oxidation in air, was again reduced to a colorless condition by the addition of hydroxylamine hydrochloride; on being acidified, the brasilin was regenerated. Fusion with potassium hydrate gave a small amount of resorcin, which was identified by color tests and by the melting point.

These tests, together with the results of Bolley's analysis, leave no doubt but that the coloring matter of sappan wood is brasilin.

ENTADA SCANDENS Benth.[21] (*Leguminoseæ*) AND SOME OF THE FISH POISONS.

Entada scandens is cosmopolitan in the Tropics of the world. It is widely distributed and quite abundant in the Philippines. The Tagalog name is *"gogo;"* Visayan and Pampangan names are *bayogo* and *balogo*. The wood of the vine is cut into thin strips, which are then beaten between stones in order thoroughly to disintegrate the fiber. In this condition *gogo* is brought into the markets. It is largely used by the natives for washing the hair. To this end the prepared *gogo* is soaked over night in cold water; the red solution makes a very good lather which renders the hair very soft without making it too dry, as is usually the case with soap. Tavera states that this treatment cures pityriasis, and I have found this to be the general belief among Spaniards and the better class of natives. There is no question but that the people who wash the head with *gogo* and then apply coconut oil have very luxuriant hair, but whether this luxuriance is due to the use of this substance can not be stated. The natives also use *gogo* for treating the itch, washing the affected parts with the decoction and at the same time briskly rubbing them with the fibers. In this way they remove the crusts that shield the mites. The treatment is successful in direct proportion to the energy of the rubbing. The tough bark of this plant is used in Ceylon for cordage and fiber.

[21] Benth. in *Hook. Journ. Bot.*, 4, 332; Baker in Hook. f. Fl. Brit. Ind., 2, 287.

The seeds are remarkable in appearance because of their size and of their beautifully polished, brown exterior. They are lenticular, flattened, and 3 to 4 centimeters in diameter. The kernel, which is often quite elastic, is mashed and used by the natives for poultices, which are believed to be useful for children in relieving colicky pains in the stomach; it is never employed for adults. The seeds contain a fatty oil, which is extracted and used in the Sunda Islands for illuminating purposes and in some places the natives also eat them, after washing out the active principle and then roasting the seeds. Rosenthaler,[22] who studied the subject, found saponin in these fruits. *Gogo* fiber is one of the plant products used in the Philippines to assist in catching fish in ponds and streams, as the soluble products so stupefy the animals as to render their capture easy.

The active principle of *gogo* belongs to the very interesting group of glucosides known as saponins, but these substances present a complicated field for chemical work, because of the difficulties encountered in purifying them. They generally are colloids which most tenaciously adsorb the different compounds with which they come in contact. The results of my efforts to isolate the saponin from *Entada scandens* are given below.

Petroleum ether takes a fatty substance from the macerated trunk fiber, which contains a trace of an alkaloid but no saponin; but the latter can be extracted either with water, methyl, or ethyl alcohol. The methods briefly are as follows:

Magnesia method.—Saponin is extracted with water, filtered, evaporated to a small volume, and dialyzed through a collodion tube. Magnesium oxide is now added and the whole evaporated to dryness on a steam bath. The residue is finely powdered and extracted with hot, absolute alcohol in a Soxhlet apparatus. This alcoholic solution is evaporated to dryness, the residue again taken up with alcohol, and from this fluid the saponin is precipitated fractionally by ether. In order to purify the product it is usually necessary to repeat the entire process. The saponin obtained by this means is beautifully white, but the yield is very poor.

Lead acetate method.—Saponin is extracted with water, filtered, precipitated by basic lead acetate, and the precipitate collected and washed. It is then suspended in dilute alcohol and decomposed by means of sodium sulphate. The precipitate is now repeatedly extracted with 80 per cent alcohol, concentrated to a small volume and dialyzed. After dialysis it is evaporated to dryness, dissolved in alcohol, and fractionally precipitated by ether. This method gives a product which has a good appearance, but one the ash content of which is very high. The use of hydrogen sulphide to decompose the lead precipitate is objectionable, because of the foul-odored substances which are then taken up in the alcoholic solution and which later can not be completely removed.

Methyl alcohol method.—The *gogo* is extracted hot, using a reflux condenser, first with petroleum ether and then with methyl alcohol, in which the saponin is quite soluble. The solution is now evaporated to dryness and the residue dissolved in water, certain gums and resins remaining behind. The aqueous solution is now filtered, the filtrate dialyzed, evaporated to dryness, powdered, and again dissolved

[22] *Arch. de Pharm.* (1903), **241**, 641.

in methyl alcohol; a small part again remaining undissolved. The solution is again filtered, concentrated to a small volume, precipitated fractionally with ether, and the ether-alcohol mixture allowed to stand over the saponin for twenty-four hours, which is sufficient time to allow any resinous substances borne down by the precipitated saponin to redissolve. The product is now filtered, and dried *in vacuo*. A repetition of the alcohol-ether precipitation will further purify the saponin. I consider this method to be the best one for isolating saponin from *gogo*. The yield is 5 to 6 per cent of the weight of macerated fiber employed. The fiber, as it is obtained in the markets, contains from 7 to 10 per cent of saponin, as is shown by the physiological tests on the crude extracts.

Saponin, as thus obtained, is a white, amorphous powder. In some cases crystalline needles, which gave all the tests for saponin, were isolated from water, but, as the ash content was very high and as the exact conditions for isolating these crystals have not yet been worked out, it is impossible as yet to state whether or not they consist of saponin or of a saponin addition product to an inorganic substance.

Saponin is rather easily soluble in water, giving a solution which is slightly acid toward litmus and congo red. It dissolves more readily in slightly alkaline than in pure water. When all dialyzable impurities such as sugars, etc., have been removed, saponin is not hygroscopic, and it is possible that the hygroscopic character of these substances mentioned in the literature may be due to impurities.

Basic lead acetate precipitates saponin in while flocks; lead acetate gives no precipitate. Barium hydrate gives a very abundant precipitate in an 8 per cent but only a very slight one in a 1 per cent solution. Saponin is readily soluble in methyl alcohol, difficultly so in cold ethyl alcohol; it is insoluble in ether, petroleum ether, chloroform, benzene, carbon tetrachloride, carbon bisulphide, acetic ester, or organic solvents in general. Saponin gives a red color with concentrated sulphuric acid; concentrated nitric acid gives no color, neither does ferric chloride. An intense, red color, which later turns to a blue, is produced with an alcoholic solution of sulphuric acid to which a little ferric chloride has been added. Selenious acid, dissolved in concentrated sulphuric acid gives a red color, much like that produced by sulphuric acid alone. Mercuric acetate, to which a drop of potassium nitrite has been added, developes an intense, purple red.

Saponin can be heated to 180° before it begins to turn brown or to show a perceptible change. It does not melt, but at a high temperature it chars, giving a burnt-sugar odor. Its solutions in water and in methyl alcohol foam very markedly, an addition of ethyl alcohol decreases this tendency. It leaves a lasting taste somewhat resembling that of an alkaline soap. It is not precipitated by saturating its solution with ammonium sulphate, as is the case with the majority of acid saponins. It shows the characteristic usual of this class of bodies of being able to hold powders in suspension; charcoal, lead sulphide, barium sulphate, barium carbonate, etc., are held so tenaciously as to render it impossible to separate them by filtration. Mercury is readily "killed" by an aqueous solution of saponin and oils are easily emulsified. It is very difficult to obtain crystals from boric or salicylic acid solutions to which a little

saponin has been added; in fact it in general prevents the crystallization of crystallizable substances. An aqueous solution of saponin does not reduce Fehling's solution, but gives with it a dark precipitate, which probably represents a saponin-copper sulphate compound. The substance contains 14 per cent of water, dried at 115°, the last traces adhering very tenaciously, so that constant weight is only reached after several hours. With Mayer's solution it gives no precipitate, with phospho-molybdic acid a blue, floculent one.

Saponin when boiled with dilute acids is decomposed to give a sapogenin and galactose. The latter was identified by galactosaczone, with a melting point of 191°, 193°, 194° in three successive recrystallizations. Saponin is also decomposed by *Penicillium* fungi which rapidly cause a separation of sapogenin; carbon dioxide being at the same time given off.

The preparation of sapogenin is simple. An aqueous solution of saponin is boiled for about one to two hours with 5 per cent hydrochloric acid, and in cooling sapogenin separates in reddish flocks. These are filtered, dissolved in hot alcohol, to which a little animal charcoal has been added, again filtered, and set aside, whereupon the substance in question precipitates. A few recrystallizations from alcohol serve to purify it.

As thus obtained, sapogenin consists of white, odorless, crystalline needles. It is insoluble in water, moderately so in cold alcohol, more so in hot. It is readily dissolved by chloroform, benzene, or carbon tetrachloride. It is insoluble in dilute acids or alkalies. Sapogenin naturally gives the same color tests with concentrated acid as saponin. It does not foam when placed in water, neither does it have any taste; if such a foaming takes place it indicates that a small impurity of saponin still remains. Sapogenin is remarkably stable toward heat, it does not melt, nor is it in any appreciable manner affected by a rise of temperature to 270°. It is apparently without physiological action, but this fact may be due only to its insolubility.

Nitric acid, potassium permanganate, or hydroiodic acid have thus far not yielded substances of a crystalline nature. A study of the constitution of sapogenin is important, as it is believed that an effective attack on the saponin problem can be made by this means, as sapogenin can be obtained in crystals which are undoubtedly pure.

Analyses of the sapogenin showed the formula to be $C_{25}H_{42}O_3$.

(I) 0.2993 gram sapogenin gave 0.2861 gram H_2O and 0.8419 gram CO_2.

(II) 0.2268 gram sapogenin gave 0.2199 gram H_2O and 0.6372 gram CO_2.

Required for $C_{25}H_{42}O_3$	Found	
	(I)	(II)
Per cent.	Per cent.	Per cent.
C=76.9	76.8	76.6
H=10.8	10.8	10.78

The physiological action of the saponins is very interesting, as all of these bodies are characterized by their great hæmolytic power; many are very irritating and many are true protoplasm poisons. The following represent typical cases of the action of saponin on animals:

Experiment A.—Guinea pig of 210 grams: 0.005 gram saponin in 1 cubic centimeter of water injected intraperitoneally. The animal was very uneasy soon after the injection. Trembling, labored breathing, and progressive weakness follow. Dead in two hours. An *autopsy* performed immediately after death shows the peritoneal cavity to be much congested, with large amounts of a bloody, serous exudate present. A microscopic examination of this fluid reveals great numbers of leucocytes, in clumps, the red blood corpuscles being dissolved and the serum deeply colored with hæmoglobin. In the heart's blood, the lysis was not so marked, but the serum was tinged with hæmoglobin. The lungs were normal. The minimum fatal dose of *entada* saponin intraperitoneally is 0.0025 gram for a guinea pig of 200 grams weight, although animals often showed dangerous symptoms with one-fifth of this dose. Injected intravenously, saponin is much more poisonous, 0.0002 killing a rabbit of 800 grams weight in two minutes. Dr. Harry T. Marshall, of the Biological Laboratory of this Bureau, has made further physiological studies on this saponin and his results are reported elsewhere in this number of the JOURNAL.

FISH POISONS USED BY THE NATIVES.

Entada scandens is one of the plants used in the Philippines as a fish poison, and it owes its efficacy in this direction to its saponin content. A saponin solution of 1 to 20,000 was prepared, and three small fish placed in it. They soon became stupefied, floating about without motion on the top of the water, and all died within two or three hours. Controls under similar conditions were not affected.

Fish poisoning is much practiced by all the wild tribes in the Islands, and also to a considerable extent in the outlying districts by peoples who are classed as civilized. The fish poison is usually prepared with considerable ceremony by the head men of a village, the various ingredients being pounded up together and then thrown into the stream or pool. The plants are often mixed with earth and rocks, the intention being to sink the noxious plants so that all parts of the water may be poisoned. Very soon, small fish begin to float on their sides on the top of the water, while the larger ones move about slowly in a stupefied and helpless manner. The natives then rush into the water and kill and catch all they can, after which there is a great feast. Many of the ingredients put into the fish poison mixtures are harmless and without effect. Some of the important ones which we have thus far obtained are cited in the following:

One of the favorite poisons is "*túba*" or "*tañgan-tañgan túba*," which is the native name for the fruit of *Croton tiglium* Linn.[23] (*Euphorbiaceæ*). This well-known tree is widely distributed in the Philippines as a cultivated or semicultivated plant. Other native names for it are

[23] Sp. Pl. (1753), 1004; Hook. f. Fl. Brit. Ind., 5, 393.

macasla, camisa, túba-camisa. The fruit contains the very poisonous toxalbumin *crotin,* which is similar to the well-known ricin and abrin. The toxic effect on fish is doubtless due to this substance. Persons who eat fish poisoned with *túba* are not disturbed, although it is considered dangerous to drink water which contains any quantity of it.

Some other fish poisons used in the Philippines and which have been examined are the following:

Anamirta cocculus W. & A.[24] (*Menispermaceæ*), which grows from British India to Malaya, and is common and widely distributed in the Philippines. The native names for this plant are *suma,* and *lactang.* The fruits are the parts of the plant used for fish poisoning. The action of this substance is due to the very poisonous bitter principle, pikrotoxin.[25] Poisoning due to eating the fish obtained by its means has often occurred, so that in some countries it has been found necessary to restrict the sale of these fruits to the pharmacist. The fruits are also used in the Philippines for preparing an antiparasitic ointment.

Albizzia saponaria Blume (*Leguminoseæ*) has a bark containing one of the saponin glucosides; the same is true of *Pithecolobium acle* Vid. (*Leguminoseæ*), *Barringtonia luzoniensis* Vid. (*Lecythidaceæ*), and *Maesa denticulata* Mez. (*Myrsinaceæ*). The saponins in these plants will be reported upon later.

Another fish poison containing saponin is from *Ganophyllum obliquum* Merr.[26] (*Sapindaceæ*), which is found in the Philippines, New Guinea, and northern Australia. In the Philippines it is rather widely distributed, but not very common. The native names are *pandapanda, gogonglañgin, calamansalay,* and *tugabi.* The bark of ganophyllum contains no alkaloids, a considerable amount of resin, and 7.2 per cent of saponin, which latter I isolated by the methyl alcohol method. When precipitated from this solvent by means of ether it is a white powder, which readily turns brown in the air. When it is added to water or methyl alcohol the solution foams strongly and in general gives the usual reactions for the saponins. The color reactions of this saponin are as follows:

Concentrated sulphuric acid, intense purple color; concentrated nitric acid, orange; concentrated hydrochloric acid, a weak, red color to the saponin but no

[24] W. & A. Prodr., **1,** 446; Hook. f. Fl. Brit. Ind., **1,** 98.

[25] *Ber. d. chem. Ges.* (1898) **31,** 2958; *Ann. Chem.* (*Liebig*), (1884) **222,** 322; *Ber. d. chem. Ges.* (1877) **10,** 83, 1100; *Monatsh. f. Chem.* (1880), **1,** 98; *Monatsh. f. Chem.* (1881), **2,** 803.

[26] This plant has recently been transferred into this family by Radlkofer, as a result of morphological studies. The occurrence of saponin in it is an additional and confirmatory proof of the correctness of the change, as many of the *Sapindaceæ* contain saponins, while none of the *Burseraceæ* in which family the genus was placed, are known to contain these substances.—E. D. M.

Rif. Merr.: *Publications of the Bureau of Government Laboratories,* Manila (1905), No. **27,** 30; G. Falcatum Blum.: Englw. in D. C. Monog. Phan., **4,** 168.

color to the acid; sulphuric acid in which has been dissolved a little selenious acid, reddish-brown; an alcoholic solution of sulphuric acid to which a drop of ferric chloride has been added, a deep wine-color; mercuric acetate containing a drop of potassium nitrite solution, a rather faint green.

This saponin is readily split by boiling with dilute acids, the sugar being galactose as in the previous instance, for it gave galactosazone of a melting point of 180°. The sapogenin obtained from it, when it is at first precipitated in the presence of acids, is very red, but it turns to a blue-black when the supernatent liquid is made alkaline. However, this sapogenin is not a dye.

The physiological behavior of saponin from *Gonophyllum obliquum* is very interesting, it being more irritating than the one from *Entada scandens*. The physiological experiments are as follows:

Experiment A.—Guinea pig of 220 grams: 1 cubic centimeter of water containing 0.033 gram of *gonophyllum* saponin was injected intraperitoneally. The injection apparently acts immediately on the sensory nerve endings in the peritoneum, as is shown by the movements and general behavior of the animal. The guinea pig is very weak in three minutes and dead in about one hour. An autopsy shows the intestinal cavity to be fiery red, due to the intense irritation caused by this drug. Much bloody serum, the corpuscles of which showed marked lysis, is also found. The urine is not bloody; the lungs slightly congested; the heart moderately dilated.

Experiment B.—Guinea pig of 210 grams: 0.5 cubic centimeter, containing 0.016 gram of saponin, given intraperitoneally. The effects are exactly the same as in Experiment A. Dead in about one hour. An autopsy showed the same results as in Experiment A, with irritation even more marked.

Experiment C.—Guinea pig of 205 grams: Injected intraperitoneally at noon with 1 cubic centimeter containing 0.008 gram of saponin. Apparently immediate, intense action on the sensory nerves of the peritoneum, as is shown by violent movements. The animal is very sick during the entire afternoon and dead on the next morning. Autopsy showed similar results to the ones in Experiments A and B. The irritation in the intestinal cavity is not so marked, but the lungs are congested and the heart dilated. The liver, kidneys and epithelial lining of the bladder are also congested and there is a large amount of bloody serum, containing hæmolized red blood corpuscles in the intestinal cavity.

Experiment D.—Guinea pig of 210 grams: 0.5 cubic centimeter, containing 0.004 gram of saponin given intraperitoneally. Pronounced effect immediately observed as in the other cases. The same results throughout as in Experiment C are observed; the animal is dead on the next morning.

Experiment E.—Guinea pig of 230 grams given 1 cubic centimeter, containing 0.002 gram intraperitoneally. The animal was very sick for forty-eight hours, after which time there was complete recovery.

Experiment F.—Guinea pig of 215 grams: 0.5 cubic centimeter, containing 0.001 gram given intraperitoneally. Immediate effects were observed as in all other cases. The same results as in Experiment E, ending in complete recovery, are noted.

These experiments demonstrate that the physiological action of *Gonophyllum* saponin is chiefly characterized by intense, local irritation but lysis is also very pronounced, as in the case of all saponins. A very much smaller dose than the one in Experiment D, if given intravenously,

is sufficient to kill a rabbit in a few minutes. The action of this saponin on fish is apparently the same as that of the one from *Entada scandens.*

These saponins are particularly advantageous for use as fish poisons, because, whereas many are very poisonous when injected, they are usually only slightly so when taken into the stomach; so that even if the fish is somewhat contaminated with these substances no harm will come from eating it.

Two fish poisons of a different class have also been examined. One is *Derris polyantha* Perk. (*Leguminoseæ*), containing a poisonous alkaloid, and the other is *Diospyros canomoi* D. C.[27] (*Ebenaceæ*), a plant which is endemic, common, and widely distributed in the Philippines, the part used being the fruit of the tree, which turns black after a few days' exposure to the air. The natives claim that the fruit is exceedingly poisonous, that it will quickly kill fish, and will even cause a crocodile to leave the water. They also maintain that the juice of the berry, when applied to the human skin, blisters it and causes it to turn black. The following preliminary study of the fruits of this plant has been made:

(*a*) Two lots of 50 grams each of the ground, fresh berries were soaked for twenty-four hours in 100 cubic centimeters of water (No. 1) and 100 cubic centimeters 1 per cent sulphuric acid (No. 2), respectively, and alkali, equivalent to the sulphuric acid, was then added to the second portion. The extract was now separated from the berry pulp in a hydraulic press. Both solutions were intensely black. No alkaloid or glucoside could be found in either.

The physiological tests were as follows:

Experiment A.—Guinea pig of 210 grams: 1 cubic centimeter of solution No. 1 given intraperitoneally. The animal is weak in a few minutes, and it is sick during this day and dead on the next morning. An autopsy reveals much irritation and congestion of the abdominal organs, with large amounts of bloody exudate, but no pus.

Experiment B.—Guinea pig of 230 grams: 1 cubic centimeter of solution No. 2 given intraperitoneally. There is marked irritation from the time of the injection with symptoms as in Experiment A, but after forty-eight hours of weakness there is complete recovery.

Experiment C.—Guinea pig of 200 grams: 1 cubic centimeter of No. 1 given subcutaneously. The substance is evidently quite irritating, the animal making efforts to bite the place of injection, it is quiet for some hours, but with no other marked effects, and complete recovery ensues.

Experiment D.—Guinea pig of 205 grams: The results duplicate Experiment C in every respect.

Experiments E and F.—On these guinea pigs an area of about 6 square centimeters is shaved and 0.5 cubic centimeter of extract No. 1 rubbed into the skin. It evidently affects the sensory nerves quite markedly. For several days afterwards the skin at the place of application showed a marked rash and appeared darkened, rough, and leathery.

(*b*) Three hundred grams of the fresh fruits were now subjected to a pressure of 400 kilos per square centimeter in a hydraulic press, 90 grams of a black liquid

[27] Prodr. (1844) **8**, 237; D. multiflora Blanco. Fl. Filip. (1837), 303; Hiern. *Monog. Eben.* (1873), 216, non Wall.

being obtained. This liquid has a very astringent taste and is acid, 10 cubic centimeters requiring 6.22 cubic centimeters of $\frac{N}{10}$ sodium hydrate for neutralization.

The following experiments show its physiological behavior:

Experiment A.—Guinea pig of 210 grams: 1 cubic centimeter of expressed juice of the berries given intraperitoneally. Uneasiness and weakness almost immediately follow; the animal is dead on the next morning. An autopsy showed very pronounced local irritation in the abdominal cavity, also a bloody serum; the lungs and heart are congested.

Experiment B.—One cubic centimeter of expressed juice is rubbed on the shaved skin of a guinea pig. Evidences of considerable uneasiness appear soon afterwards. The next day a rash has become evident and the skin is dark and like a very brittle, rough leather.

A peculiar acid is present in the *Diospyros* fruits, which seems to belong to the tannic acid series, and to which I provisionally assign the irritating properties of the plant. With ferric chloride it gives a greenish-black precipitate and it is precipitated from strong solutions by dilute hydrochloric or sulphuric acid. Lime water throws down a greenish-black calcium salt. Gelatine forms a leather-like mass and albumin gives a precipitate. Lead acetate precipitates it to a slight extent, basic lead acetate completely. An alcoholic solution of thymol, followed by concentrated sulphuric acid which is run under the solution, gives a rose colored ring, or with the same acid added directly to the mixture, a turbid, rose-colored solution. The rigid proof that this tannic acid is the active principle of the plant will have to be brought later as much more work on it is necessary. It may be remarked that the extract of these berries alone makes a very fair ink, in which respect it might be compared to *Coriaria thyifoia,* the ink plant of New Granada and New Zealand.

TINOSPORA CRISPA Miers.[28] (*Menispermaceæ*).

This plant is widely distributed in British India and Malaya. The Tagalog name is "*macabuhay.*" This word means literally "you may live," and it expresses the very general belief in the marvelous medicinal virtues of this plant. In the Philippines it is considered to be a panacea to be applied to all bodily afflictions.

The stem is the part employed in medicine, although in India, where the plant also has a great reputation, the leaves and roots are also used. The plant is officinal in the Pharmacopœia of India. It has been recommended by various physicians as a febrifuge and also for gout, for secondary syphilis, as a powerful emetic for snake bite, leprosy, chronic rheumatism, dyspepsia, and as a cure for insanity, while a necklace made of small pieces of the stem is worn as a remedy for jaundice. The above gives some idea of the wide range of diseases which *macabuhay* is supposed to cure. European physicians in the Philippines state that

[28] Contrib. 3, 34; Hook f. et Thoms. in Hook. f. Fl. Brit. Ind., 1, 96.

they have yet to see a case in which they are certain that a cure has been effective by its use, and I found a few Filipinos who were sceptical as to its efficiency. One Filipino doctor stated that the only thing it was good for was to wean babies, the aqueous extract being applied to the nipple. Any one who has ever experienced the exceedingly bitter and persistent taste of this extract will not doubt its efficacy for this purpose.

Very little is known about the chemistry of the plant. Flückiger [29] found in the stem of *Tinospora cordifolia,* a very closely related species, a small amount of berberin, and a bitter glucoside, which latter he considered to be the active principle of the plant. Other chemists have reported small amounts of berberin.

I have examined a large quantity of the stems of *macabuhay.* The air dry plants contain 67 per cent of water, and drying does not affect the bitter taste. Repeated boiling with water extracts all of the bitter principle. In most of the plants which I have examined no alkaloid could be found either in the aqueous extract or in that obtained by the use of dilute acids; however, in a few instances a trace was present but this did not give the tests for berberine according to the method of Gordin,[30] although a rose color was obtained with chlorine water. Dr. Clover, of this Bureau, in making a preliminary study of this plant, also found no alkaloid.

Substances which, after being boiled with acids, reduce Fehling's solution were also present. Such bodies were obtained in various ways, but always in an amorphous and resin-like condition. As these compounds in every case proved to be physiologically inactive on guinea pigs, even when used in enormous doses, and as even after persistent endeavor I failed to obtain them in a crystalline condition, it was not considered advisable to devote further time to this plant.

To obtain data as to any possible poisonous substance in this plant, a very concentrated aqueous extract was prepared as follows:

One hundred grams of crushed *macabuhay* was boiled with water for six hours. It was then filtered and all liquids pressed from the residue in a hydraulic press. This removed practically all the bitter material from the plant. The extract so obtained was concentrated *in vacuo* to 20 cubic centimeters. Injections of 2 cubic centimeters of this extract were given to guinea pigs, both subcutaneously and intraperitoneally. No effect was noted. The action of this solution on amœbæ was also studied, but these organisms lived and thrived as well in the extract as in the culture media.

These experiments are in accord with tests made by Dr. Cushny at the University of Michigan on macabuhay material furnished him by Dr. P. L. Sherman, of this Bureau. He was unable to find any physiologically active substances in the plant.

[29] Ref. in Watts. Dict. Econ. Plants of Ind., 6, Part IV, 64.
[30] *Arch. d. Pharm.* (1902), 240, 146.

Macabuhay must therefore be classed with the "bitters," the value of which as tonics, if they have any, is in some way intimately related to their bitter taste.

ARGEMONE MEXICANA Linn.[31] (*Papaveraceæ*).

This weed is a native of tropical America, but has been introduced into the Philippines and British India. It is common about towns in these Islands. The native names are *diluario, cachumba, casumbang-aso.* Padre Blanco states that the yellow juice of this plant is used by the natives to heal "fissures of the corners of the eyes," and indeed, the name *Argemone* is derived from that of a small ulcer of the eye, for which this plant is supposed to be a specific. The seeds yield a yellowish, fixed oil which is laxative and is supposed to relieve the pain of cholera.[32] It is a drying oil, and in the future may be in demand as a medium for paints. The Spaniards in these Islands considered the seeds more narcotic than opium. The oil has been used in India as a purgative and it has been highly praised by the physicians of that country, but they have not been able to detect the narcotic properties which are so widely believed in by the natives here.[33] The dose is 2 to 4 grams. The plant is officinal in the Mexican Pharmacopœia, and it has always been in great repute among Spanish American peoples. Tavera says: "The flowers are narcotic by virtue of a principle resembling morphine, perhaps identical with that alkaloid." Charbonnier[34] made a chemical study of *Argemone mexicana* and claimed that he found morphine; Dragendorff[35] states that it is supposed to contain that substance. This belief seems to have crept into many works of reference, as even very recent ones give the statement that the alkaloid found in this plant is morphine.[36] As *Argemone mexicana* is in the same family with the poppy (*Papaver somniferum*) it seemed likely that these statements might be correct, although I have been unable to find any later chemical investigations on this plant.

In view of the literature on the subject it was very desirable to discover whether the alkaloid in this plant really is morphine or not, especially as an opium law has recently been passed in the Philippines. In a country where morphine is heavily taxed, it should be known if there is a weed along the roadside which may possibly become a source for the supply of this drug.

Several kilos of the plants, in all stages of growth, were collected, together with several hundred grams of seeds. Preliminary tests showed the presence of an alkaloid.

[31] Hook. f. et Thoms. in Hook. f. Brit. Ind., 1, 117.
[32] Tavera; *Loc. cit.*
[33] Watts: Dict. Econ. Plants of Ind., 1, 307.
[34] *Journ. de Pharm.* (5) (1868), 7, 348.
[35] Heilpflanzen (ed. 1898).
[36] See Pictet-Wolfenstein, Die Pflanzenalkaloide (ed. 1900), 238.

Five kilos of ground plants and seeds were extracted with chloroform containing a little ammonia. After adding a small amount of one-half per cent acetic acid, the green-colored chloroform extract was distilled, the aqueous liquid remaining, filtered and concentrated to a small bulk *in vacuo*. It was then placed in the cold storage for a few days. When next examined a quantity of yellow, needle-shaped crystals had separated; these were recrystallized several times from water. Tests proved this substance to be berberin. An acetone compound was prepared according to Gaze.[37] The characteristic red color was obtained with chlorine water, and potassium iodide completely precipitated the substance. The further tests were carried out according to the method of Gordin [38] and left no doubt that the substance in hand was really berberin.

All parts of the plant were now examined for morphine, but in none of the extracts could any be found, although another alkaloid is present in small amount. I was not able to identify the latter, but can state positively that it is not morphine.

ERYTHROXYLON BURMANICUM Griff.[39] (*Erythroxylaceæ*).

This plant has been found from Burmah to the Malayan Peninsula, Andaman Islands, Sumatra, Java, and Luzon, in which last place it is local and not abundant. Cocaïne is secured from *Erythroxylon coca*, and it has been claimed that it has been found in small quantities in several species of the genus.[40] Thus, a content of 0.03 per cent of this alkaloid was claimed for *Erythroxylon burmanicum*.

In view of these facts a supply of leaves and bark of this plant was obtained. The brown bark has a slightly bitter taste.

Four hundred grams of the finely ground bark were extracted with petroleum ether containing a small amount of ammonia, according to assay method of Lyons.[41] As no alkaloid was obtained, the bark was extracted with dilute acids, but neither an alkaloid or a glucoside could be found, and the solution was also physiologically inactive.

Ten kilos of the fresh leaves, which were received in a very good condition, were extracted with petroleum ether containing a small amount of ammonia. The solvent was evaporated to a small bulk and shaken out with one-half per cent hydrochloric acid. Not a trace of alkaloid was present. Various other standard methods of extraction were used with the leaves with negative results; neither were any of the extracts physiologically active.

So far as is known this plant is not used by the natives in any of their medicines.

CAESALPINIA BONDUCELLA Flem.[42] (*Leguminoseæ*).

This plant is cosmopolitan in the Tropics and is common along the seashore throughout the Philippines. The common English name for the seed is the *bonduc* seed, or fever nut; in Tagalog it is *calumbibit*.

[37] *Arch. der Pharm.*, **228**, 607.
[38] *Arch. der Pharm.* (1902), **240**, 146.
[39] Griff: Notul., **4**, 468; Hook f. Fl. Brit. Ind., **1**, 414.
[40] Ref. in Dragendorff, Heilpflanzen (1898), 343.
[41] Lyons: Assay of Drugs (ed. 1899), 48.
[42] Asiat. Res., **11**, 159; Baker in Hook. f. Fl. Brit. Ind., **2**, 254.

The hard, smooth-coated seeds are exceedingly common in the Islands, the native boys using them in a game similar to marbles. They are purchasable at all the shops and are quite cheap, the price being 10 cents, United States currency, per pound, and all classes of natives consider them to be a good medicine for "stomach troubles." An adult will eat from ten to twelve nuts, and if there is no relief in an hour or two the dose is repeated, and the dosage for youths and infants is in proportion. Nausea and symptoms of poisoning are said to be produced when too many are taken. The kernels are also supposed to be very efficacious as an antiperiodic and tonic; in India a powder prepared from them and black pepper, ground together, has a considerable repute for the same purposes and as a febrifuge. The active principle of the nuts is supposed to be a substance termed bonducin, which was isolated by Heckel and Schlagdenhauffen,[43] who assigned to this body the formula $C_{14}H_{15}O_5$. I found that ten kernels weighed 9.8 grams; ten nuts 21 grams.

Several kilos of the nuts were obtained and examined. The taste of the kernel is exceedingly bitter. Dilute acids or acid-alcohol do not extract either alkaloid or glucoside, but there is about 20 per cent of a light-yellow, fixed oil in the seeds, which can be obtained in the usual manner by pressing or extracting.

One kilo of the finely ground kernels was extracted hot with alcohol with the aid of a reflux condenser. The alcohol was distilled and the oily residue dissolved in a small amount of chloroform. This solution was now washed successively with dilute alkalies, acids, and water, filtered, and then poured into 5 volumes of petroleum ether. The bonducin then separated as a white powder. This was filtered and purified by successive treatments with chloroform and petroleum ether.

Obtained in this way bonducin is a white, amorphous powder with a nut-like odor and a resinous feel and aspect. It has an exceedingly bitter taste which it lends to water, in which it is only very slightly soluble. It dissolves to a greater extent in dilute hydrochloric acid, but after the solution is boiled no reduction of Fehling's solution takes place, so that bonducin is not a glucoside.

It is readily soluble in chloroform and glacial acetic acid and in ether with but a slight residue; it is taken up by petroleum ether with very great difficulty. Strong alkalies slowly dissolve bonducin, as they do most resins. The substance gives a blue color with concentrated hydrochloric acid, which becomes purple on standing; the same reagent with a little ferric chloride gives a strong greenish-yellow; a salmon color is obtained with concentrated nitric acid, and concentrated sulphuric acid produces a brown, which soon goes to a deep purple. Bonducin from which all ether-insoluble matter has been carefully removed, gives an intense rose-red color with concentrated hydrochloric acid, instead of a blue as with the ordinary preparation.

Another method of obtaining bonducin is by extracting the ground nuts with ether; when the solvent has been evaporated, the resin separates from the oil as a white powder; this separation can be rendered more complete by adding petroleum ether.

[43] *Compt. rend. Acad. d. sc.*, Par. (1886), **103**, 89.

Various attempts were made to obtain bonducin in a crystalline condition or to produce a crystalline derivative from it. Solutions of the resin in different solvents were left in the cold storage for weeks without result.

The resin is not changed by boiling for one and one-half hours with 100 cubic centimeters of 95 per cent alcohol to which 10 grams of concentrated sulphuric acid have been added.

A different result was obtained with alcoholic potash.

Five grams of bonducin were boiled on a reflux condenser for one hour with alcoholic potash. On pouring into water, nothing separated. The aqueous, alkaline solution was now extracted with ether and on evaporation this solvent left 2.1 grams of a brown resin. Both of the resins behaved much alike, giving the usual color reaction excepting with concentrated hydrochloric acid, which produces no color with either, and with nitric acid, which gives the salmon color only with the acid product. It was not found possible to obtain a crystalline derivative from either resin.

All the properties of bonducin show that it is a resinous mixture, the nature of which it would probably be exceedingly difficult to elucidate. It is obvious that no formula can be assigned to it.

A solution containing one part of bonducin to 1,000 parts water and which is exceedingly bitter was prepared for physiological tests. It has no effect when injected into guinea pigs. Amœbæ were suspended in a drop of this solution for three hours without showing any change in their movements. The appellation of the "poor man's quinine" which is given to *bonduc* seeds in India would therefore not seem to be very applicable.

PLANTS CONTAINING PURGING OILS.

Plants of this class are numerous in the Philippines. I have examined *Aleurites moluccana* Willd.,[44] *Aleurites trisperma* Blanc. and *Jatropha curcas* Linn., all of the *Euphorbiaceæ*, the nuts of which have the reputation of containing efficient purging oils. Thus, Tavera mentions the use of the oil of *Aleurites moluccana* by Dr. O. Roche, in doses of 1 to 2 ounces, and states that Doctor Xerez, municipal physician of Sampaloc, has had frequent occasion to employ the oil. The chemical properties of the two *Aleurites* oils are being studied by others in this Laboratory. I have investigated the seeds with the view of isolating the constituents of the oil which might be physiologically active, as I hoped to obtain a toxalbumin similar to abrin, recin, or crotin.

Many attempts to isolate such a substance from the seeds of *Aleurites moluccana* were made.

[44] Sp. Pl., 4, 590; Hook. f. Fl. Brit. Ind., 5, 384.

Habitat: Eastern India to southern China, Malaya, northern Australia, and Polynesia, naturalized in tropical America; widely distributed and abundant in the Philippines. Native name, *lumbang*.

The crushed seeds were freed from their oil, either by pressing or extracting with ether. The seed cake was now extracted with 10 per cent sodium chloride, in the cold, the solution being kept sterile by means of a little toluol or chloroform. It was then filtered and the albumins separated by saturation with ammonium sulphate, the precipitate being then collected and dialysed until free from sulphates,[45] the dialysed solution being usually prepared of such a strength that 1 cubic centimeter corresponded to 1 gram of seeds.

The solution gives pronounced reactions for albumins. Two cubic centimeters will kill a guinea pig of about 200 grams' weight in about twenty-four hours; boiling the solution for two minutes destroys the toxic power. When evaporated *in vacuo* over sulphuric acid, a white powder remains which also gives tests for albumins, but this powder is not toxic.

The albumin in the solution can also be precipitated by alcohol, but in a nontoxic form. Very many experiments were made in an attempt to obtain the toxin in a more concentrated condition, but all were unsuccessful. All the solutions used in these experiments were sterile. The results of the work on a large number of guinea pigs and rabbits, which was carried out with Dr. Strong, Chief of the Biological Laboratory,[46] would seem to indicate that the seeds of *Aleurites moluccana* contain a toxalbumin which is either unstable, or present in minute amount, or only very moderately poisonous.

Injections of 1 cubic centimeter of the oil of *Aleurites moluccana,* both subcutaneously and intraperitoneally, into guinea pigs of about 200 grams, weight had no effect; neither did the acids produced by saponifying the oil and given in doses of one cubic centimeter behave differently. Negative results were also obtained when 1 to 2 cubic centimeters of the oil were ingested by these animals, although this latter quantity is over ten times the dose given by Dr. O. Roche. The oil which I used was carefully prepared and neutral, so that, if it were active, the results could be attributed to it and not to the acids or other substances which might be present in the commercial article.

Similar experiences as regards a toxalbumin were found after a study of the seeds of *Aleurites trisperma.*

Jatropha curcus Linn.[47] (*Euphorbiaceæ*) is a native of tropical

[45] In all my dialyses I have used collodion tubes prepared according to the method of Gorsline. (Contributions to Medical Research, dedicated to Dr. Vaughan by his students, Ann Arbor, Mich. (1903), p. 390.) I can recommend them very highly. The speed of dialysis is very much greater than with parchment paper, and the tubes are quickly and easily prepared. I have found that the collodion sack slips off from the glass tube over which it is prepared very easily if, just before dipping the glass tube in the collodion, one rubs over it a little soap suds, which are then wiped off with a towel, so as to leave a thin, invisible coating of soap on the glass.

[46] I wish to express my thanks to Dr. Strong for his interest in this work.

[47] Sp. Pl. (1753), 1006; Hook. f. Fl. Brit. Ind., 5, 383.

America, and is now distributed throughout the Tropics, being common as a hedge plant in the Philippines. The native names are *tuba, casla, tava-tava, tawa-tawa.* It is widely used in the Philippines as a purgative; in fact many natives do not distinguish between the seed of this plant and the castor bean. As a matter of fact, the oil is strongly purgative, and the seeds are even more so, so that one of the latter is an ample dose, and three will cause dangerous symptoms. The oil is present in the seeds to the extent of about 25 per cent, and in the latter I have found a substance which behaves like a toxalbumin. If it proves to be such, Dr. Strong has kindly consented to take up its study. Robert and Siegel [48] claimed to have found such a substance in *Jatropha curcus* fruits.

I have made arrangements with Dr. W. E. Musgrave, of the Biological Laboratory, whereby he will make a study of these purging oils. We hope to be able in the future to state what substances are the active principles of these oils. It has been noted previously that they are rather uncertain in their action, behaving as if an accidental mixture might cause the purging.

[48] *Bull. of Pham.* (1893).

THE TOXIC ACTION OF SAPONIN.

By Raymond Foss Bacon and Harry T. Marshall.
(*From the Biological and Chemical Laboratories, Bureau of Science.*)

In connection with the previous article, a few experiments were made in order to determine whether the saponin described therein has toxic properties similar to those of other saponins.

Most of the studies upon this subject have appeared from Kobert's laboratory at Dorpat (4; 5; 7; 11). The saponin substances examined there were found to be general protoplasmic poisons—that is, substances which injure or kill all forms of protoplasm with which they come in contact, without producing any alteration recognizable by present chemical methods. When rubbed on the skin saponin exerted no action and was not absorbed. It was strongly irritating when applied to the conjunctival mucous membrane. When injected subcutaneously into frogs it was quickly absorbed and acted upon nerves and muscles. In warm-blooded animals there was little or no absorption, the saponin causing an aseptic abscess in the subcutaneous tissue. Intravenous injection of even small amounts proved fatal for cats and dogs, the animals dying without hæmaturia and without diarrhœa.

Saponin exerts an immediately deleterious action on striated muscle and heart muscle, the change being evident upon microscopic examination. Sensory and motor nerve fibers, nerve endings, and the central nervous system are all affected seriously. Saponin also acts upon the digestive tract, causing inflammation, and increasing peristalsis. Kobert suggests that this action is due to thrombosis of the intestinal vessels, starting from the detritus of hæmolysed corpuscles. A 5 per cent solution proved to be rapidly fatal for a worm devoid of a chitinous covering (*Taenia cucumerina*), while the protected *Ascaris* was not affected after twenty hours spent in such a solution.

The saponin substances dissolve the blood corpuscles of probably all mammals, and they penetrate the corpuscles very rapidly. It seems likely that the hæmolytic action of these substances depends upon hydration and liquefaction of the (hypothetical) cell membrane.

As was pointed out by Ehrlich (3), the hæmolytic action of the

saponins is very different from that of serum, the former being comparable rather to that of the alkaloids where only a loose and transitory union is effected between the cell and the chemical agent.

The hæmolytic action of saponin was studied by Ransom (8). He found slight quantitative differences in the action of saponin on blood from different species. Lysis occurs more rapidly with concentrated saponin and blood than it does when either is diluted. Saponin becomes bound both to the corpuscles and to the serum, 0.75 cubic centimeter of either fixing 2 milligrams of saponin, so that it does not subsequently act on red corpuscles. He found that this action depended upon cholesterin, and obtained the same result with pure cholesterin dissolved in lecithin, lecithin alone being inert. One cubic centimeter of a 1 per cent solution of cholesterin in ether was added to 20 cubic centimeters of a 0.1 per cent solution of saponin in 0.85 per cent salt solution, shaken and kept at 36° for a few hours. At the end at this time the saponin-cholesterin mixture exerted no action on dog's blood and had no local irritating action when placed under the skin of frogs.

From his examination of corpuscles undergoing hæmolysis, Ransom thinks that saponin acts first upon the surface of the corpuscles, later upon the interior. Kobert, however, classes saponin as one of those substances which most readily penetrates the corpuscles.

Ransom's work was confirmed by Schanzenbach (10), who also found that injections of saponin lower the resistance of animals to the action of bacteria.

Attention has been turned to the hæmolytic action of saponin and to the similarity of the interaction of saponin and cholesterin to that of toxin and antitoxin.

Both Bashford (1) and Besredka (2) failed in their attempts to produce an immunity in animals inoculated with saponin, thus contradicting the claims of Pohl, and Sachs (9) explains the action of cholesterin by assuming that it acts only as a solvent for the saponin. However, it would be difficult to understand why saponin previously dissolved in cholesterin should be any less injurious to corpuscles than the saponin alone. Madsen and Noguchi (6) studied the cholesterin-saponin combination by the methods of physical chemistry and were able to plot a curve for the interaction of these bodies similar to the curves obtained for various toxin-antitoxin mixtures.[1]

[1] Since this article has been in press a work by Bunting (*J. Exp. Med.* (1906), 8, 625–646) has been received. Bunting studied experimental anæmias in rabbits. To produce anæmia he used saponin "which is intensely hæmolytic to rabbit blood in the test tube, and to which, apparently, a tolerance is not so easily established" (as to ricin). The fatal dose was 1.5 to 2 milligrams per kilo of animal. Injections of sublethal doses were followed by slight changes in the leucocytes,

Stewart (12) found that saponin acts more slowly at 0°; that it acts upon blood treated with formalin as readily as upon fresh blood; that it increases the conductivity of the blood. The nuclei of the red corpuscles of Necturus were not affected by saponin. He concluded that saponin acts first upon the envelopes of the corpuscles, increasing their permeability to electrolytes, thus agreeing with Ransom.

EXPERIMENTAL WORK.

Saponin from *Entada scandens* proved highly toxic for rabbits and guinea pigs. When diluted with normal salt solution to a concentration of 1 to 200 and injected into the peritoneal cavity, 2.5 milligrams of saponin per 100 grams of animal was uniformly fatal, while a quarter of this amount (0.6 milligram per 100 grams of animal) killed in several instances. No gross lesions were found in animals dying within a few hours; in those living for a longer period a localized peritonitis was occasionally met with, and one guinea pig died of intussusception. The results were better when a dilution of between 1:500 and 1:1,000 was used for injection. Subcutaneous inoculations of a 1:200 solution were followed by abscesses, and a high dilution, given intravenously, proved to be rapidly fatal.

The saponin is powerfully hæmolytic. 0.0050 cubic centimeter of a one-half of 1 per cent solution (0.025 milligram) completely dissolved 1 cubic centimeter of a 5 per cent suspension of rabbit's corpucles which were freed from serum, and half of this amount produced hæmolysis of the serum-free corpuscles of the guinea pig.

Experiment showed that the corpuscles of the rabbit can absorb more than the simple hæmolysing dose of saponin, for in one case as much as four times this quantity was required to produce hæmolysis of two consecutive cubic centimeters of blood suspension. This agrees with Ransom's results.

Saponin loses its hæmolytic power after the addition of serum, 0.1 cubic centimeter of horse's serum protecting 1 cubic centimeter of a 5 per cent suspension of guinea pig's corpuscles against twice the dissolving dose of saponin, and 0.01 cubic centimeter of serum just allowing complete hæmolysis to take place.

reduction in erythrocytes, accumulation of pigment in lymphoid organs, and, after intravenous injection, the prompt appearance of large numbers of nucleated red cells in the circulation, normoblasts, megaloblasts, and naked pyknotic nuclei. After repeated doses the blood picture resembled that of a primary anæmia in man, together with a relative and absolute decrease of polymorphonuclears and increase of mononuclears. Intravenous injections affected almost only the hæmopoietic organs, acting with especial severity upon the cells and capillaries of the bone marrow.

No immunity could be demonstrated in rabbits or guinea pigs previously treated by intraperitoneal doses of saponin or of a saponin-serum mixture, although differences were observed in the susceptibility of the corpuscles of different animals of the same species.

Amœbæ from dysenteric patients and from tap water are destroyed by saponin. After a few seconds in a solution of a strength of 1 to 400 the amœbæ burst with explosive suddenness, the ectosarc disappearing, the granules flying in every direction, and only traces of the nucleus remaining, surrounded by a few coarse granules. When more dilute saponin is used, amœboid activity increases for a few minutes; the amœba then becomes more or less circular, while undulations pass around the periphery, where the clear space enlarges, both centrally (forcing the granules close around the central nucleus) and peripherally, the total diameter increasing. The granular endosarc seems to be walled in by an inner membrane of the ectosarc, the increase in the size of the amœba occurring between the two layers of the ectosarc. As the size increases, amœboid motion diminishes. After a short period, varying with the concentration of the saponin, a change suddenly takes place in the endosarc; the granules become larger, stream into the clear, swollen ectosarc and fill the whole body of the amœba as far as the limiting membrane. A few seconds later the amœba either explodes in all directions, or, more commonly, bursts through a pseudopod-like projection, which suddenly appears.[2]

It was at first thought that a simple physical explanation might be found for the bursting of the amœbæ. The property which saponins possess of holding solids in suspension so that they can not be separated by filtration has already been mentioned. It was thought, perhaps, that saponins would also remove ions and dissolved substances from a solution, perhaps holding them in colloidal suspension, in which case a simple osmotic pressure theory of the bursting of amœbæ could be developed. For, as the saponin is not readily dialyzable, its power of removing dissolved substances from the system (amœba and solution) would be confined to the solution outside of the amœba. Hence, because of a resulting change in osmotic equilibrium, water would rush into the amœba, in which organism more dissolved substances would be present than in the outside solution, until the ectosarc of the amœba would be ruptured explosively. The experiments to decide on the value of this theory show that it is not the true explanation, and that the latter will probably need to be sought in a specific action of the saponin, possibly on the extosarc, corresponding to the theory of the action of saponin on blood corpuscles as given by Stewart (12).

[2] A similar action of neutral red upon amœbæ has been observed by Dr. W. E. Musgrave.

The experiments on which these conclusions are based are as follows:

(1) The resistance in ohms (R) was measured in a certain conductivity cell, the following solutions being used:

(*a*) 25 cc. 1 per cent sodium chloride solution,	R= 72.4
(*b*) 25 cc. of 0.5 per cent saponin solution+0.08 per cent sodium chloride,	R= 63.9
(*c*) 25 cc. of (*a*)+25 cc. distilled water,	R=138.1
(*d*) 25 cc. of (*b*)+25 cc. distilled water,	R=120.2
(*e*) 25 cc. of (*a*)+25 cc. of (*b*),	R= 66.45
(*e*) 25 cc. of (*a*)+25 cc. of (*b*),	R= 65.9
(*e*) 25 cc. of (*a*)+25 cc. of (*b*),	R= 65.9
(*e*) 25 cc. of (*a*)+25 cc. of (*b*),	R= 66.5
(*e*) 25 cc. of (*a*)+25 cc. of (*b*),	R= 67.0
(*e*) 25 cc. of (*a*)+25 cc. of (*b*),	R= 66.5
Calculated [from (*c*) and (*d*)] resistance, if one solution has no effect on the ionization of the other, for (*e*) in ohms,	65.4

Hence a very slight reduction in conductivity is observed on adding saponin. Another series gave similar results as follows:

(*a*) 0.1 per cent sodium chloride solution	R= 51.5
(*b*) 0.05 per cent sodium chloride solution	R= 138.5
(*c*) 0.5 per cent saponin solution	R=1,033.0
(*d*) 25 cc. of (*b*)+25 cc. of 1 per cent saponin	R= 129.7
(*d*) 25 cc. of (*b*)+25 cc. of 1 per cent saponin	R= 130.0
Calculated [from (*b*) and (*c*)] for (*d*),	R= 122.2

Hence the decrease of conductivity is about 6 per cent or the osmotic pressure change would approximately be 0.0456 atmosphere, corresponding to 3.42 centimeters of mercury or about 40 centimeters of water.

The change observed is small and, taken in connection with the fact that a 0.5 per cent saponin+1 per cent sodium chloride solution bursts amœbæ as readily as 0.5 per cent saponin alone, it indicates that the laws of osmosis alone probably do not suffice to account for the phenomenon.

Saponin exerts a similar action upon some flagellates found in tap water and stagnant ponds, the motility ceasing, and the organisms swelling and usually bursting.

It was noted that air bacteria grew abundantly in a solution of crude saponin. A 0.05 per cent solution of purified saponin did not affect the motility of cholera vibrios nor retard their growth on an agar slant.

Agar plates were made from the discharges of a case of bacillary dysentery, and at the same time parallel series of plates were made with acid and with alkaline agar containing 0.1, 0.5, and 1.0 cubic centimeter of saponin. The drug did not affect either the number or size of the colonies developing.

These few experiments indicate that this saponin has toxic properties closely resembling those possessed by other substances of the same nature. The experiments with amœbæ indicate that it acts first upon the outside membrane, as was held by Ransom and Stewart, and that the penetration

described by Kobert is not primary. The fact that bacteria can grow in the presence of saponin indicates that it is not a universal protoplasmic poison, although it is possible that the bacteria may be protected against the drug by their membranes.

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CONTRIBUTIONS TO THE PHYSIOGRAPHY OF THE PHILIPPINE ISLANDS.

I. CEBU ISLAND.

By Warren D. Smith.
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CONTENTS.

Introduction.
Discussion.
Brief statement of the geology.
Physiography.
The Cordillera Central.
The intermediate uplands.
The coves.
The coastal plain.
Economic relations.
Conclusion.

INTRODUCTION.

I have chosen the physiography of Cebu for the first paper of this series for a number of reasons, the first of which is that my acquaintance with that island is more intimate than with any other of the larger islands of the Philippine Archipelago; the second, that historically it is the oldest place of European settlement in the group; the third, that it is the most populous island for its size; and the fourth, that its economic, social, and political history is so peculiarly related to that of its physiography and geology that I feel capable of a more scientific inquiry into these relationships in Cebu than in the case of other islands, where my conclusions would be more or less conjectural.

The primary object of my visit to Cebu was to make an investigation of the coal and oil deposits; the data for this paper were acquired during three months of rather extended reconnaissance.

A very admirable and fairly complete geologic and physiographic description of Cebu has come from the able pen of Sr. Enrique Abella y Casariego, formerly chief engineer of the *Cuerpo de Ingenieros de Minas*. As this work is in Spanish, it is not available to many geological readers and for this reason I feel that I will be pardoned for drawing upon it rather copiously. It should be stated that in this paper

Abella's general scheme of subdividing the island into units has been adopted, but I believe I have treated the subject from a somewhat new point of view.[1]

Miguel Legaspi, in 1565, writing from Cebu, stated: "We are at the gate and in the vicinity of the most fortunate countries of the world, and the most remote; it is three hundred leagues or thereabouts farther than great China, Burnei, Java, Lauson, Samatra, Malaco, Malaca, Patan, Siam, Lequeios, Japan, and other rich and large provinces."

With prophetic insight, the great explorer realized the importance of the port of Cebu and planted the first European colony there. Although Legaspi afterwards established another settlement to the north (Manila), which in the intervening centuries has gone beyond the southern port, still Cebu is practically the controlling center of trade in the Visayas, and is becoming the shipping point for much of northern Mindanao. The fact that recently it has been made an open port brings to it many trading ships from Europe and the China coast which do not touch Manila at all.

The building of over a hundred miles of broad-gauge railroad, the possession of both coal and oil, the former in economically paying quantities, and probably the latter also, will greatly augment the assets of this island and promise a still greater prosperity to it.

GEOLOGICAL SUMMARY.

In studying the physiography of a district it is necessary briefly to outline its geological history, and this is best initiated by a tabular statement of the stratigraphy. The following table has been adapted from that of Abella with whom, save in one or two particulars, I agree:

TABLE I.—*Provisional tabular statement of the stratigraphy of Cebu.*

Stratigraphic position and probable age.	Lithology and field relations.
Recent	Alluvial deposits and living reefs.
Pliocene and Pleistocene	Coral reefs which appear to grade uninterruptedly from the Pliocene to the Present.
Upper Miocene	Coralline limestone and marls with *Orbitoides* and *Vicarya callosa*.
Unconformity	Shown by discordance in dip, not by contact.
Eocene	Limestone with *Nummulites? scabra?* Lam.
Eocene	Sandstones, shales, and coal seams.
Unconformity	Basal conglomerate.
Pre-Tertiary (?)	Andesitic and basaltic flows later than the hypobyssal rocks.
Pre-Tertiary	Hypobyssal-igneous pre-Miocene felsites, diorites, and crystalline schists.

[1] I am making a translation of Abella's work, entitled "*Rápida descripción física, geológica y minera de la Isla de Cebú*" (*archipiélago Filipino*), Madrid, Tello, 1886, and in all probability this will be published as a document of this Government.

THE IGNEOUS COMPLEX.

The core of the island is largely plutonic rock, in some places felsitic, almost a typical basalt, elsewhere a diorite, and again very much like a granite. Though Abella reported granite on this island, so far I have seen none.

This igneous rock is found in all the streams cutting any of the three ranges shown in a cross section of the island. A very blue, hard, and extremely fine-grained variety was found constituting Mount Maupa, one of the landmarks of Cebu. This mountain, with a conical top, rises above the range of which it is a part and is very conspicuous from the sea. Locally it is referred to as the sugar-loaf mountain, although I am unable to detect the resemblance. A porphyritic rock, which is a hornblende-andesite, is seen in the vicinity of Compostela, on the tramroad to the group of mines back in the hills.

A conglomerate of varying thickness succeeds above the igneous complex. So far as I know, this conglomerate is always present and is conclusive proof that the igneous rock is not of the nature of an intrusive mass. Were it such, the difficulties of mining might be increased enormously.

Stratigraphically, above the conglomerate comes a series which is very difficult to demarcate and to separate into its integral parts. In his two years' work on this island, Abella did not attempt to map this series separately. It comprises alternating beds of shale, sandstone, and limestone, generally unfossiliferous. Above this come the coal measures proper, consisting of a gray shale at the base, thickness unknown, a black, firm coal occuring in at least two seams, the first averaging 1.5 meters in thickness, although greater thicknesses have been reported; this is followed by a firm, yellowish-gray, seemingly unfossiliferous sandstone; above this lies a second seam of coal varying from 30 centimeters to 76 centimeters. This is of a much inferior grade, being characterized by shale and slate partings. Above this latter seam is a bedded limestone said by Abella to contain nummulites. In my search through these beds I have found no form which I could with certainty class as such. As Mac-Pherson,[2] of the "*Comision del Mapa geologico de España*," concurred with Abella in this diagnosis, I shall accept it provisionally.

In the vicinity of the Guila-Guila property, at the headwaters of the Mananga River, I found a limestone formation having about the same stratigraphic position as Abella's nummulite beds, but a rather close search revealed no nummulites. However, it is extremely rich in the

[2] See footnote to page 109, Abella's *La Isla de Cebu*.

genus *Orbitoides* (Lepidocyclina).[3] This limestone is, to my mind, unquestionably upper Miocene, equivalent to the *Gaj of the Sind*, India. At one point, in a cutting on the Danao tramroad about two kilometers below the old mines, limestone probably containing numulites was found. One form I have identified as possibly belonging to the species *N. scabra* Lam. This limestone appears to be unconformable with and below the orbitoidal beds.

I have serious doubt as to whether Abella is correct in drawing so sharp a line between his two limestone series. According to the map accompanying his "Rapid Description of the Island of Cebu" he regards the limestone of Cebu as of two distinct ages, Nummulitic-Tertiary Eocene and post-Pliocene. The limestone mantle found capping the *Cordillera* and its outlying ranges contains *Orbitoides* (Lepidocyclina) *verbeeki*, thus being correlated with the upper beds in Masbate, southern and northern Luzon, and Formosa. Abella leaves the Miocene and Pliocene entirely out of account; furthermore, I do not believe that further study will show any stratigraphic break between the Pliocene limestone and the living reefs.

PHYSIOGRAPHY.

THE CORDILLERA CENTRAL.

The Cordillera Central may be said to form the backbone of the island. It extends north and south, corresponding to the long axis of Cebu and also to one of the main tectonic lines of the Archipelago. Its greatest elevation does not in all probability exceed 1,000 meters. No triangulation has as yet been done in the interior. It is partially wooded and almost without inhabitants, the only human beings to be found there are scattered bands of *ladrones*, or *pulajanes*, as they are locally termed, and the Constabulary who hunt them. Wild and almost inaccessible, underlain by igneous rock which does not support a very flourishing flora, a region of pronounced relief, it is not very enticing even to the geologist, and the native avoids it as he would the plague. (Pl. I shows a portion of the *Cordillera* country.)

Although the total elevation for a mountainous country is not great, the relief of central Cebu is exceedingly pronounced. There are two reasons for this; the first and chief one being the short, horizontal distance to sea level, which enhances the declivity, and the second, the scarcity of vegetation. These conditions are favorable for the development of steep profiles and V-shaped cross sections in the streams. Nevertheless, outcrops are few and the talus is very heavy on most of the valley

[3] Further study, it is expected, will show these forms to be *Lepidocyclina insulæ-natalis* Jones & Chapman, or closely related to that form from the Miocene of Christmas Island.

This note is added later owing to the receipt of some literature and correspondence from Mr. Chapman after the body of this paper had gone to press.—W. D. S.

walls. In some isolated portions there is still a capping of coralline limestone which gives a more or less even crest to the range, but where this is absent, as in the region of Mount Maupa (southwest of Cebu city, about 30 kilometers) the outline is serrated.

The main folding in the island has taken place in an east-west direction, so that the axis of the folding runs north and south. The effect of this is to give the streams in the vicinity of the *Cordillera* a north and south direction. At their sources they may be east and west and the same may be true farther down, where they turn again to cut at right angles through the foothills. There is a minor cross folding north and south which somewhat modifies this arrangement of the drainage and which also causes the frequent sags in the high line of the central portions and a complete dying out of the ridge to the north. A reference to Abella's geological sketch map of Cebu[4] will show that the courses of the streams on the various formations differ greatly. For instance, attention is called to the Cot-cot, the Baliguaguon, the Minanga, the Argao, etc. Rivers. After the discussion of the several physiographic regions, I shall take up in detail one of these rivers and treat its physiography from source to mouth.

THE INTERMEDIATE UPLANDS.

I have given this name to all the elevated region between the *Cordillera* and the coastal plains. It includes the more or less isolated areas called *mesetas* by Abella. We might, with perfect justification, consider some parts of this large region as being made up of even two other physiographic divisions, but for the present paper we shall neglect such a separation.

The surface rock is for the most part either limestone or marl, in some places sandstone or a coral sand formation. The limestone varies from Miocene to post-Pliocene.[5]

The geological events which have transpired to bring about the resulting features of this upland country are many and have been quite

[4] Burritt: The Coal Measures of the Philippines, *Bull. Min. Bur.* (1901), map p. 16, or accompanying Abella's La Isla de Cebú.

[5] One feature of the limestone is interesting and may be noted in passing. In an old, abandoned tunnel which was run in on the orbitoidal (i. e., Miocene) limestone, I found edible bird's nests (*Hirundo esculenta*). Posewitz[6] maintains that stage γ of the Pliocene may be inferred wherever these are found. It is true that the cave under consideration is not a natural one, although it appears to be so, and these birds built their nests here in lieu of a more natural situation. If one relied on this criterion alone and considered this particular place he would very naturally call the limestone in question Pliocene. However, I can not believe that any geologist would trust to evidence like this for correlation. Doubtless all that is meant is that caves containing these nests are more abundant in the Pliocene. I concur with Mr. Becker in calling this a most curious method of geological determination.

[6] Posewitz, Theo.: Borneo, Berlin (1891), 190.

complex. In the first place, the older sedimentaries were profoundly folded and probably also much faulted; in the second, erosion set in and truncated many of these folded beds; in the third, subsidence occurred and a coralline mantle was laid down upon these truncated folds, and in the fourth, the whole region received a thrust from below in which elevation took place, but it was an unequal elevation, with tilting east, west, north, and south. The north and south tilt, which, however, may be decidedly more recent than the east and west one, is best seen in the vicinity of Argao, where the marine terraces incline to the north at an angle of about five degrees.

Mr. Becker[7] has remarked upon the even sky line of the central part of the island and explains this as resulting from the peculiar growth of coral reefs, which grow up to a limiting plane, the surface of the water. This is undoubtedly correct, and the coralline mantle has suffered but little tilting in the region of the *Cordillera*. In the lower regions the even sky line is still well preserved in many places, but the tilting is marked.

Since my return from the field, Mr. Bailey Willis's brief discussion of his physiographic studies in Europe, appearing in the Carnegie Yearbook,[8] has suggested to me possible explanations for some of these phenomena, for which a ready solution did not seem to be at hand, and the Carpathian type of mountains, with their peculiar physiography, namely, folded Neocene strata subsequently tilted and warped with sink holes, seems to find an analogy in Cebu.

Mr. Willis also emphasizes the fact that the *growth* of mountains is distinct from the existence of mountains by virtue of their structure. I am inclined to think that those of Cebu have *grown* rather than that they are due to inherent structure, for were it not for the great subsequent erosion, one might start from the coast and climb toward the *Cordillera* without being aware of anything more than a moderate ascent, for it is the afterwork of the streams which has made Cebu appear to be mountainous. The photograph on Plate II shows what this work has been; indeed, the similarity of this region to the Benguet country of northern Luzon is quite marked, although in reality its elevation is from 2,000 to 3,000 feet less.

Extended sections are rare, but one in Butuanon Creek was photographed, showing the local warping in the Pliocene limestone. We believe this phenomenon to be quite widespread over Cebu. (Pl. III.)

[7] Becker, G. F.: Geology of the Philippine Islands, *U. S. G. S. 21st An. Rep.* (1902), 561.

[8] Bailey Willis: *Fourth Year Book*, Carnegie Inst. (1905), 196.

HANGING VALLEYS.

The phenomenon of hanging valleys is not by any means common in Cebu, but there are two or three quite remarkable examples. One is found on the west coast, in the vicinity of Barili, where there is a beautiful waterfall of about 50 meters, and another, much more typical, in the Guila-Guila country where the Bocanit drops off the upland country into the valley of the Mananga, some 250 feet below. (See Pl. IV.) The outcrop near the top of the wall is a limestone, very rich in *Orbitoides*. The underlying rock is igneous; although the higher valley is still young, there is a marked difference between the cross sections of the two, the upper one being more on the order shown by fig. 1.

FIG. 1.

The lower one is a typical cañon, and is diagramatically sketched in fig. 2.

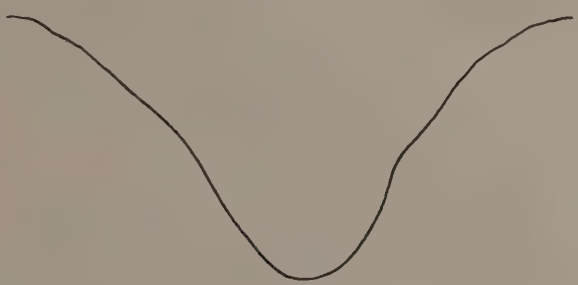

FIG. 2.

We need not believe in any unusual series of events, other than a rather rapid rate of elevation, to explain this phenomenon. Evidences of elevation are abundant throughout the whole length of Cebu, as has been pointed out by Becker, Abella, and others.

Another factor might be suggested as having played some part in producing the great difference in these two valleys, namely, the quantity of water available for the work of erosion on the plateau and in the

deeper valley. The country rock underlying the highlands is limestone, abounding in sinks and cracks, so that meteoric waters do not gather so well into streams and hence do not become available for degradational work. On the other hand, the lower stream taps all or at least a large part of the underground water from the overlying formations, besides gathering the contributions from the higher stream itself.

The photograph (Pl. V) shows the cañon-like appearance of the Mananga just below the point where the Bocanit enters, and also the men at work constructing the new Cebu-Toledo road and the difficult nature of this work. In the Philippines it is absolutely imperative that the roads should be built well above the highest water of these mountain streams and also high enough so that the rock on the upper slopes shall be reduced to a minimum.

In referring to this phenomenon of hanging valleys Salisbury [8] has spoken of the two streams as being *out of topographic adjustment.* This lack of topographic adjustment always points to some disturbing influence, is due to many divers causes, and is exhibited in various forms. The hanging valley is nearly always an attendant phenomenon in glaciated mountainous regions. I do not find any other reasons for supposing that there has ever been any glaciation in Cebu, while I do believe the explanation which considers perfectly normal events to be sufficient in this case.

The uplands do not support as large a population as one would suppose to be the case and in many portions, chiefly in the central ones, the natives live huddled in squalid barrios or reconcentration camps. Corn is the principal product, but even this crop is cultivated in a sporadic, half-hearted, and primitive way, nature being relied on to do the larger part of the work. Plate VI is a view of typical upland country in the region of the Compostela-Carmen coal fields.

THE COVES ("CUENCAS" OF ABELLA).

The best land on the island of Cebu is to be found in the valleys of such streams as the Pandan, Jacupan, Carmen, etc. These meander through beautiful, broad, flat-bottomed valleys, which are very much like those of East Tennessee and North Carolina in the United States. They are generally flat bottomed, the level of the valley floor being usually not over 50 meters above the sea, they are often roughly circular in outline, and in nearly every case the stream which occupies the valley issues from it through a narrow, cañon-like cut in an igneous formation which acts as a barrier. A diagram, as follows, will probably convey a better idea of the relations pertaining in these valleys:

[8] Salisbury, R. D., and Chamberlin, T. C.: Geology, New York (1904), 1, 154.

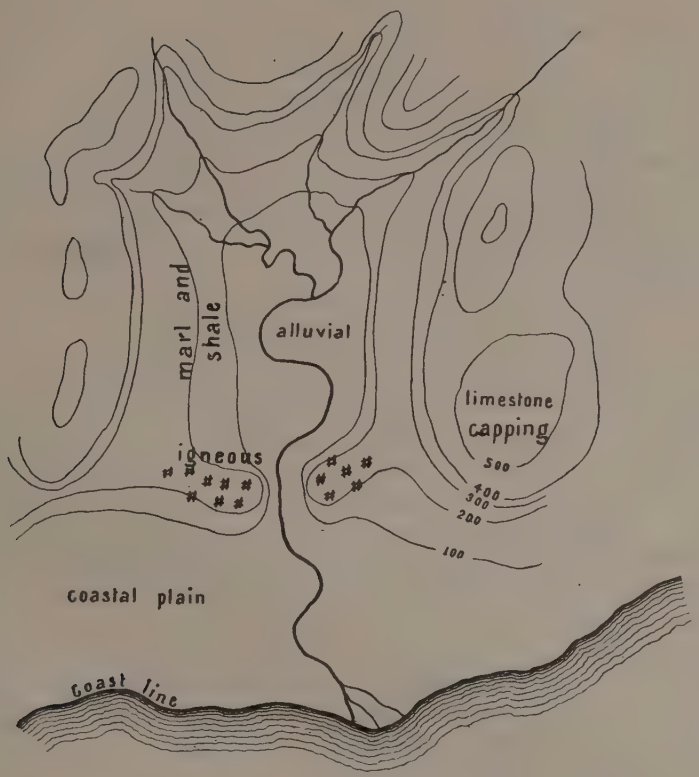

FIG. 3.

The process of formation is analogous to that of a mill pond in a stream. Instead of there being a damming up of water, there is ponding, as it were, of silt and degradational material brought down by the stream, and so a local flood plain is formed. In these coves the streams have every appearance of old age, with meanders especially well developed. The are flood plains, but not flood plains as we usually think of them—that is, the ones produced by material deposited during times of overflow. They are formed largely as a result of *lateral planation*. The importance to agriculture of this process whereby a stream works back and forth over a tract of ground, can not be overestimated. To-day, one of the fundamental principles of agriculture is that of *rotation of crops*. When man, in his ignorance or negligence, will not rotate his crops, nature rotates the ground and thus guards against the inevitable drain on the capacity of the soil. In the case of the Nile, a fresh layer of

alluvium is spread over a large part of the old ground, whereas here the new alluvium which is spread over the surface is small, but slowly the whole is worked over and turned under by this lateral cutting and deposition of the streams.

In these coves all the contours are gentle and rounded, save at the lower ends, where the streams usually issue through picturesque gorges. Just as the scenery of the *Cordillera* is wild, rugged, and forbidding, so here is it mild, domestic, and inviting. Plate VII is a view looking eastward over the Carmen Valley; the mantle of coral limestone on the hills across the valley should be noted.

THE COASTAL PLAINS.

Cebu throughout most of its extent has remarkably little coastal plain, and yet it is this exceedingly narrow and interrupted strip which supports her proportionally enormous population. It has a foundation of coral reef on which has been deposited the débris of the hills, Piedmont River deposits. In this débris is material from the decay of all manner of rocks—diorite, andesite, basalt, sandstone, and limestone—through and over which the streams have worked their way from the highlands to the lowlands. The gathering together of all these constituents in the plain soils has rendered them very rich, as they consist of many varieties of elements. This raised shelf is, likewise, a result of manifold processes of building. With a foundation of coral rock, these plains have been constructed by deltas, alluvial fans of the rivers coming down from the mountains, and by the work of the sea, as is manifested by bars and spits. Undoubtedly much of the planeness of this lower country has been produced by wave cutting. This plain has not a perfectly even and uniform surface, because all these different agencies have left on the topography their mark which time has not entirely obliterated.

To make a critical study of the coastal plain, we must review its mode, or modes, of origin. As islands in regions of volcanic disturbance, as is the case in the Philippines, emerge from the sea, usually with little or no coastal plain, we may begin with a hypothetical case and show the normal course of development of such a plain. If we neglect the part played by the reefs, the progress would be about as represented in the three diagrams (taken from Chamberlin and Salisbury).[9]

[9] Chamberlin, T. C., and Salisbury, R. D.: Geology: Processes and their results, New York (1904), 1, 58.

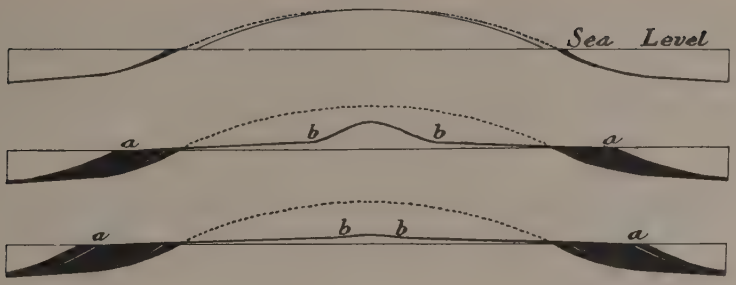

FIG. 4.—Diagrams to illustrate the effect of rain erosion on an island when all the eroded material is deposited about the shore. The black portions represent deposition. The dotted lines represent the original surface. The several diagrams represent successive stages in the process. (After Chamberlin and Salisbury.)

It is seen from these figures that while there is a shifting of material from the highlands to the sea-border, there is no diminution in the bulk of the mass, but only a change in its form. It can also be seen that the portion between the levels of high and low water approach more nearly a true plain, for along this belt the waves, tidal or otherwise, are continuously at work levelling down any irregularities. Beginning from here, in either direction, toward the shore or toward the sea, the profile departs greatly from the horizontal. If the island were gradually to subside, the water would encroach on the land and the waves would tend to plane off the latter, carrying the horizontality of the profile curve farther and farther inland. If, on the other hand, the islands were rising, the plain would grow seaward and there would be little change in the upper portion of the profile.

Now, if we suppose that reefs are forming around the island, which is rising at the same time, the growth of this platform seaward would be greatly quickened. Coral reefs make ideal foundations upon which to build a plain, because they grow up to a limiting level, namely, the surface of the water. When the coast becomes sufficiently elevated to bring these reefs above the water, we already have a flat surface which usually has a very slight slope toward deep water. At the edge of this coral platform the slope is very sudden and very great, though just at the edge the reef is slightly higher, the result of wave action, no doubt. For the most part the coastal plain of Cebu is of this origin. This is well seen by an examination of the plain north of the city of Cebu, just west of Mabolo, and in the neighborhood of Mandaue.

Rivers build many parts of typical coastal plains in the form of delta deposits. The best example of this class of formation which Cebu affords is probably the one at Argao. A delta deposit may be distinguished sometimes by its triangular shape and always by its peculiar cross section in which two series of beds can be seen. In the lower portion of a section of sufficient depth the layers are seen to dip at rather high angles, whereas

above these lies a series which is more nearly horizontal, or to be exact, which has the same gradient as the stream itself. The streams, as elevation continues, will be engorged in their old deltas, while they build new ones farther out to sea.

MANANGA RIVER.

The Mananga is typical and, as an example, will be discussed separately. A critical physiographic study of this river from its source in the *Cordillera* to the sea, is most instructive. It is selected because it is easily reached from the city of Cebu, and it presents nearly all the features of interest pertaining to the other streams of the island.

Where it rises in the region of the *Cordillera* the declivity is at a maximum, and therefore the numerous tributaries are short, comparatively straight, and join the main stream at right angles. The latter is oriented north and south, because it follows the syncline in the limestone. In this part of its course it is a structural stream. Its valley is broad and shallow, in striking contrast to the conditions in its lower course.

At the boundary between the older limestone and the igneous formation, the stream swings sharply to the east and makes its tortuous way across to the younger limestone. In traversing the igneous formation it flows at the bottom of a deep and narrow cañon, winding back and forth to avoid the harder phases of the volcanic rock, which within short limits varies greatly in physical and chemical composition. In this portion of its course the Mananga would be called an antecedent stream—that is to say, it keeps the general direction it had when it was on the limestone which overlies the igneous rock. In the former part of its course it was a *consequent* stream, flowing to the east as a *consequence* of the slope of the formations. Having become well intrenched, it worked down to the basement rock or became superimposed upon it, without having its general direction changed.

When the Mananga finally leaves the igneous rock it again becomes a *consequent* stream. In this lower portion its valley once more widens to a very broad, fertile, cove-like area, the valley of Jacupan. A local change in the character of the limestone formation, which being largely coral sand becomes very soft, and the occurrence of marl deposits account for this.

Still farther down we come to the gravel and sand plain near the sea, where the once vigorous and eroding stream is sluggish as it passes across old, dead, coral shelves finally to dip into the Mactan Sea. In no portion is the Mananga navigable even for bancas. In fact, this lack of depth is true of all the streams of the island, the condition principally being due to lack of sufficient feeding ground to support large streams, to limited plain country, and to the character of the rocks. The lack of certain classes of vegetation offers an added factor. The absence of even one good, navigable stream connecting the coast with the interior produces a profound difference in the economy of the people.

ECONOMIC RELATIONS.

I will now attempt to outline the connection between the economic relations and the physiography and geology of Cebu.

As has been mentioned above, the *Cordillera* region is an undesirable abode for human beings, it affords little in the way of sustenance, its esthetical influence passes over the heads of hungry and hunted beings, the very streams seem to leave it in haste, and the luxurious vegetation of the lower country does not aspire to it. The Molave (*Vitex littoralis*) and Narra (*Pterocarpus indicus*) are prominent among the trees. Neither do the uplands support the life expected of them. Here, the phyisography is not so much against the existence of human beings as is the geology. It is not necessary to state to those who may read this paper that a limestone soil is capable of producing a profitable vegetation, for all who know the "Blue Grass" region of the United States are aware of the fact that the underlying rock is limestone. However, there are other profound differences which have given rise to a very poor soil in the one region and a marvelously rich one in the other.

The underlying rock in the uplands of Cebu is largely limestone, as is the case in the other region cited, but the lime of these rocks does not remain to form a constituent of the soil; it is readily soluble and passes down the streams to be deposited on the lowlands as travertine and other deposits, or eventually to reach the sea. In the "Blue Grass" region we have a basin from which the lime is not as readily removed but where it remains in place.

When we come to the coves, we have the favorable conditions cited in the case of the "Blue Grass" country, and here are located the sugar *haciendas*, the great cornfields, and vegetable gardens of the island.

Very little rice is grown in these bottom lands, because of one very important feature of the soil. One might argue that the reason is not a physical one, but is purely arbitrary because the *haciendero* prefers sugar and corn to rice, but when it is remembered that rice is really more needed in these Islands than sugar or corn, and that thousands of piculs are imported every year from the China coast to supply the deficiency, it will be seen that there must be another cause for this lack. This is found in the fact that rice needs an impervious substratum to hold the water with which the paddies must be flooded, and this is almost entirely lacking in the valley areas of Cebu.

Although Cebu is the largest hemp depot south of Manila, comparatively very little abacá comes from this island. A recent investigation carried on by Mr. Richmond, of this Bureau,[10] has shown that potash is a large and important constituent in the fiber and juice of the abacá, more being contained in the juice and fiber than in the waste, and as

[10] *Phil. Journ. Science* (1906), 1, 451.

we find the potash content to be high among the mineral values of this plant, we may argue that it requires such a high amount as a requisite for its growth. A fairly exhaustive search over the island and a microscopical examination of a large number of the rocks from Cebu has shown them to be remarkably deficient in potash-bearing minerals. On the other hand, it can be demonstrated that the rocks from the well-known abacá districts are of a class which contain a considerable percentage of potash. It is not for a moment contended that other factors, such as drainage, humidity, etc., do not have much to do with this question, and for the present I will not discuss it further, as I intend to dwell more upon it in a future paper on the rocks and soil relations of Albay Province, which is one of the most flourishing of our abacá districts.

Almost nine-tenths of Cebu's great population is to be found on the alluvial plain, and here the chief products are rice and coconuts. The soil in this situation is admirably adapted to rice culture, as the stiff paddy clay holds the water around the roots of the plants, but nevertheless this crop is not as extensively grown as it might be. The coconut flourishes along the littoral.

Cebu from the time of the landing of Magellan, nearly four hundred years ago, has been a land of trouble. That the human factor, the native and also the European, has played a part in fostering these conditions can not be gainsaid, but there are far deeper causes, which are material, physiographic, and geologic, matters of environment, peculiar to islands and especially peculiar to Cebu, which have played their part. These causes are as follows, especial stress being laid on the order in which they are given: (1) Tropical climate, (2) great population, (3) island habitat, (4) mountainous interior with narrow and interrupted coastal plain.

It is the last factor which I wish to emphasize a little more fully, leaving the other points undiscussed.

I have pointed out that the *Cordillera* is unfavorable as an abode for man; that the uplands, to support a population, require strenuous and improved agricultural methods; the coves are in the hands of a few. Owing to the physiography, therefore, the native must live at the coast, or, in other words, he is not encouraged to leave the sea and to go very far into the interior to take up agricultural pursuits. Plate VIII shows a portion of the coastal plain with the mountains rising abruptly back of it. The city in the foreground is Cebu.

It is a well-known fact that the more primitive a people the smaller is the number which can find subsistence on a given area. For instance, the little Kingdom of Saxony can support an enormous proportion per square mile, but many factors, such as division of labor, the great number of vocations in life which spring up with an advanced civilization, the facilities for bringing in food stuffs from the outside, etc., make this possible. In more or less primitive communities each individual requires

a large range, to borrow a biological term, because each one procures his or her own daily subsistence. This oftentimes necessitates miles of roaming on sea and land. Just as this fact has led to conflicts in the past, and still causes them in the lower animals, so it will to-day in the higher communities. Example after example might be given where whole groups have become extinct because of these factors, but one will be sufficient. In Jurassic times in North America there lived the great and strange group of mammals known as the Dinosaurs—these were of such prodigious proportions and required such extensive ranging grounds (they were both herbivorous and carnivorous) that they became a menace to themselves. They disappeared because of their very unwieldiness, their own strength and power finally working toward their downfall.

The trouble in Cebu is largely economic, and is a result of material causes. Physical factors such as I have outlined are deep seated and have been at work before governments and human laws were instituted. Naturally, the solution of the problems presented in this island lies in the reduction of the individual range, in division of labor, in putting into motion the host of units, human and material, now unorganized and idle. There is no danger, as it was once thought, that the community of interests, the introduction of machinery, etc., will cause some to be pushed to the wall in the economic struggle.

With these will come new vocations, not known before, and they will be largely industrial, thus leading the native out into ever-widening circles of experience and larger and larger spheres of influence.

To accomplish these things it will not be necessary for him to leave his natural home, but he must study the things about him—the topography of his country, that he may control economic conditions; the streams, with a view to utilizing their water power; the strata of the earth, to mine from them mineral wealth; the soil, that he may get the most from his crops.

With economic conditions in a settled state, and that means a healthy state—the social and political phases will settle themselves.

ILLUSTRATIONS.

PLATE I. View of portion of the *Cordillera* from Camp Walker. Elevation about 3,000 feet.

II. The dissected upland country in the region of the Compostela coal fields.

III. Warped limestone in Butuanon Creek.

IV. Hanging valley of the Bocanit. View from across the Mananga Cañon.

V. Mananga Cañon, showing working party on the new Cebu-Toledo road.

VI. Another view of the upland country, Mount Mangilao in the background.

VII. The fertile Carmen Valley (looking east). Note the mantle of coral limestone on the distant hills.

VIII. The port of Cebu, showing topography of the country immediately back of it.

Photo by Smith.

PLATE I.

Photo by Smith.

PLATE II.

Photo by Smith.

PLATE III.

Photo by Tatom.

PLATE IV.

Photo by Tatom.

PLATE V.

Photo by Smith.

PLATE VI.

Photo by Smith.

PLATE VII.

Photo by Tatom.

PLATE VIII.

AGENESIS OF THE VERMIFORM APPENDIX.

By Harry T. Marshall and Ralph T. Edwards.[1]
(*From the Biological Laboratory, Bureau of Science.*)

Variations in the size, shape, and position of the cæcum are not particularly uncommon, though usually these lie within narrow limits.

Differences in position, length, and mesenteric attachment of the appendix are very common. It is usually stated that the length averages from 5 to 8 centimeters, the extremes being between 1 and 33 centimeters. According to Treves, four general types of appendix and cæcum are encountered; these depend in part upon the shape of the appendix and in part upon the degree to which the development of the lateral terminal sacculus (haustrum) of the cæcum exceeds that of the mesial terminal sacculus. The right sacculus is the larger in nine out of ten subjects.

According to Gegenbaur, the embryonic cæcum develops unevenly; one part develops fully and forms the adult cæcum, while the growth of the terminal portion is arrested at an early stage, leaving a conical tube terminating the cæcum at the time of birth. This is the condition described by Treves as the fœtal type of appendix. Gegenbaur apparently considers this the normal condition in the new born, the narrowing of the appendix and the development of the right haustrum of the cæcum occurring subsequently. Quain states that in the great majority of cases these changes begin before birth, and this is the prevailing view. The embryogeny of the cæcum and appendix was carefully studied by Kelly and Hurdon (4) in the series of human embryos collected by Professor Mall and Mr. Max Brödel at the Johns Hopkins University. The cæcum first appears at the fifth week of fœtal life as a slight swelling near the most anterior portion of the intestinal loop. A transient process, like the vermiform appendix, appears at the lower end of the cæcum as a bud, sometimes showing a cavity continuous with that of the gut. This structure disappears about the eighth week, leaving no trace. The true appendix develops as an extension from the primitive cæcum, having the caliber of the latter. About the seventh or eighth week a primary differentiation occurs into a large, proximal pouch and a smaller distal one. The diminution from the larger to the smaller

[1] Read before the Manila Medical Society October 1, 1906.

pouch may be sudden, or funnel shaped. The cæcum continues to enlarge, making the disproportion between it and the appendix more and more conspicuous. At or about the time of birth a secondary differentiation occurs. The large intestine has up to this time possessed a uniform, longitudinal muscle coat like that of the small intestine. At this period the longitudinal muscle splits into three longitudinal bundles, between which the intestine projects as hernia-like protrusions. The transverse constrictions (*plicae semilunares caeci et coli*) between the several haustra represent the position of the larger vessels of the cæcum and colon. The longitudinal muscle is not separated into bands over the appendix, the three longitudinal bands of the cæcum converging toward the root of the appendix.

Complete congenital absence of the appendix is rare; other conditions simulating this condition are intussusception of the appendix (1), inclusion of the appendix between peritoneal folds or in scar tissue, and obliterating appendicitis.

Kelly and Hurdon[2] state that appendices have been described which are very short (Huntington, 5 millimeters; Bryant, 6 millimeters, etc.). They consider that most writers describing apparent examples of complete absence of the appendix are in error and have overlooked an obliterated appendix adherent to the cæcum. They state that authentic cases have been reported by Huntington (two cases), by Zuckerkandl, and by Bryant. The subject is reviewed by Schridde (5), who searched the literature of the last hundred years and found only six cases which he considered definitely established, and four others which he regarded as doubtful. The cases cited are: (1) Puchelt; no trace of appendix. (2) I. Gerlach; appendix 3 millimeters long. (3) Merling; two doubtful cases. (4) Hunter; no trace of appendix on a cæcum appearing in an inguinal hernia. (5) Autenrieth; hernia containing a cæcum with no appendix. (6) Meckel; absence of appendix in a woman whose intestines were otherwise normal. (7) Fawcett and Blachford; absence of appendix once in 350 cadavers.

Schridde's specimen was obtained from a female infant dead of tuberculosis. There were neither peritoneal adhesions, nor lesions of the peritoneum, nor other congenital defects. The appendix was absent. The cæcum was longer than normal, egg-shaped, free from mensentery, completely enveloped in peritoneum, and projected laterally from the lower end of the colon. The cæcum showed six haustra on the lateral aspect. The three longitudinal muscle bundles did not unite, but formed a triangle at the lower end of the cæcum. After studying the appendix in man, monkeys, and lower animals, Schridde concluded that the normal cæcum should show four lateral haustra, and he believed that the two extra haustra present in his case represented the appendix.

From his review of the literature he concludes that there are hitherto no conclusive examples of a total absence of the appendix, as this can not definitely be established without counting the haustra of the cæcum.

It seems from Schridde's description that he was not dealing with

[2] *Loc. cit.*, p. 136.

agenesis of the appendix, but with a case in which the usual arrest of development did not occur in the appendicular portion of the embryonic cæcum.

We have been able to find only one other example in more recent literature. Ferguson (3) mentions, without comment, the fact that in his series of 200 dissections, congenital absence of the appendix was noted once.

Ellsworth Eliot (2) reported a case operated on for recurring attacks of pain over the ileo-cæcal region. A fibrous cord, free from smooth muscle and surrounded by fat, was the only trace of appendix found. Dr. Stafford, of the Civil Hospital, informs me that he and Major E. C. Carter had a similar case not very long ago.

The specimen here described came from an adult, male Filipino dead of cholera. There was no abdominal scar, nor were there other deformities; the peritoneum was free from adhesions; only the lower end of the cæcum was free, the mesenteric attachment extending nearly to its tip and almost up to the point of union of the three longitudinal muscle bands. There was no trace of an appendix. The longitudinal bands in the specimen united at a point on the posterior, inferior surface of the cæcum to the mesial side of the axis of the cæcum. At this point there was a small, papular elevation about 6 millimeters across and about 2 millimeters high which was the only rudiment of appendix to be found. It is to be noted that below the ileo-cæcal junction there was one large cæcal pouch on the right, or lateral aspect, which was partially subdivided into four shallow haustra, and one smaller haustrum on the left, or mesial aspect of the cæcum. On the lower end of the ileum opposite its mesenteric attachment there was a free fold of mesentery containing a little fat, corresponding to the embryonic meso-appendix, or ileo-colic fold. This was removed in preparing the specimen and only its attachment to the ileum is visible in the illustration. On opening the hardened specimen, a few circular folds of mucosa were seen surrounding a shallow depression corresponding to the orifice of the appendix. Sections show that the mucosa has dipped down to occupy this depression. The dip in the mucosa can be followed in serial sections as a gland-like tube, which runs diagonally through the mucosa of the cæcum, bends sharply on itself, passes through the submucosa, and ends abruptly after penetrating rather less than half way through the circular muscle of the cæcum. At the point of origin, where its dimensions are greatest, the invagination measures 6 millimeters by 3 millimeters, the size decreasing to its tip. In structure it consists of a tube of mucous membrane presenting many simple glands, having the structure of the crypts of Lieberkühn, and rich in mucous cells. Between the glands are many lymphoid follicles. Surrounding the mucosa is loose, connective tissue quite abundantly supplied with vessels. Van Gieson stains show that the rudiment has no muscle coat. The muscle fibers of the cæcum are separated partly

by the small tip of the rudimentary appendix with its submucosa, but these muscle fibers are definitely part of the circular muscle of the cæcum. There is no evidence of inflammation in the sections.

SUMMARY.

In this case, which presented no signs of inflammation of the peritoneum, and showed no other congenital anomalies, there was no appendix visible on external examination of the cæcum, and on microscopic examination only a rudimentary structure could be found, which extended as a shallow invagination of the mucosa of the cæcum from its lumen, to end between the fibers of the circular muscle of the cæcum. The latter was subdivided into four shallow haustra. The rudimentary structure showed only mucosa, and no muscular or peritoneal coat of its own. It is interesting that the ileo-colic fold remained.

From the features here summarized we regard this case as an example of agenesis of the appendix.

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ILLUSTRATIONS.

PLATE I. Anterior-inferior view.

A. Attachment of ileo-colic band.

B. Anterior longitudinal muscle.

C. Rudimentary appendix.

Between A and C, several lines indicating small accumulations of fat beneath the serous coat of cæcum.

II. Posterior-superior view.

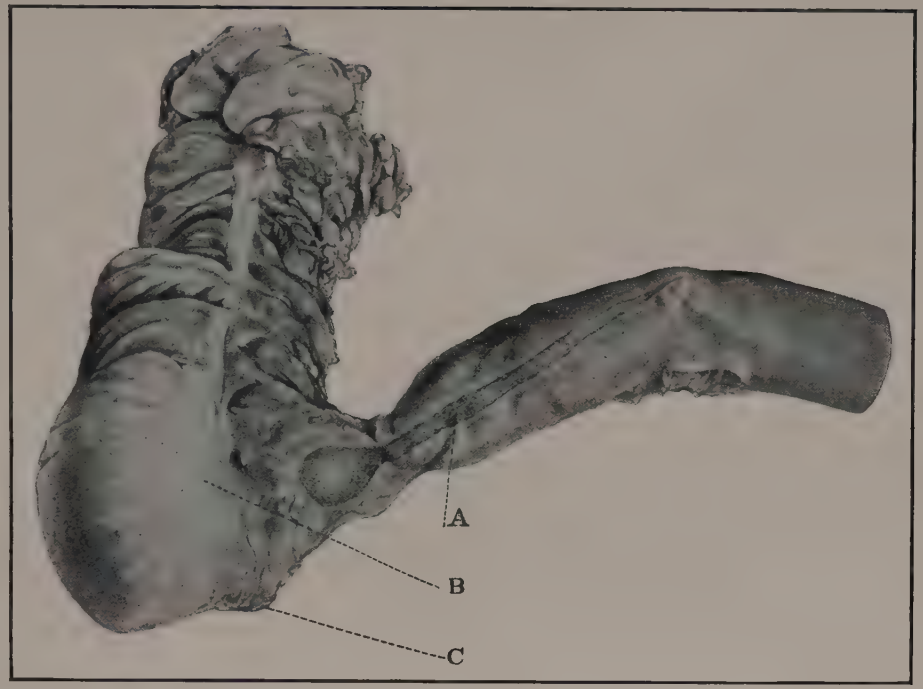
A. Appendix, turned to show most prominently.

B. End of lateral longitudinal muscle, spreading from B as a band to appendix, and in a fan shape over cæcum.

C, D. Second and third *plicae semilunares* of cæcum.

The mesenteric longitudinal muscle is not well indicated. A small band of its fibers cross the ileo-cæcal junction to the root of appendix.

III. Photograph, anterior view, showing the anterior and lateral longitudinal muscles and the four shallow haustra of the cæcum.



Drawn by T. Espinosa, 1906.

PLATE I.

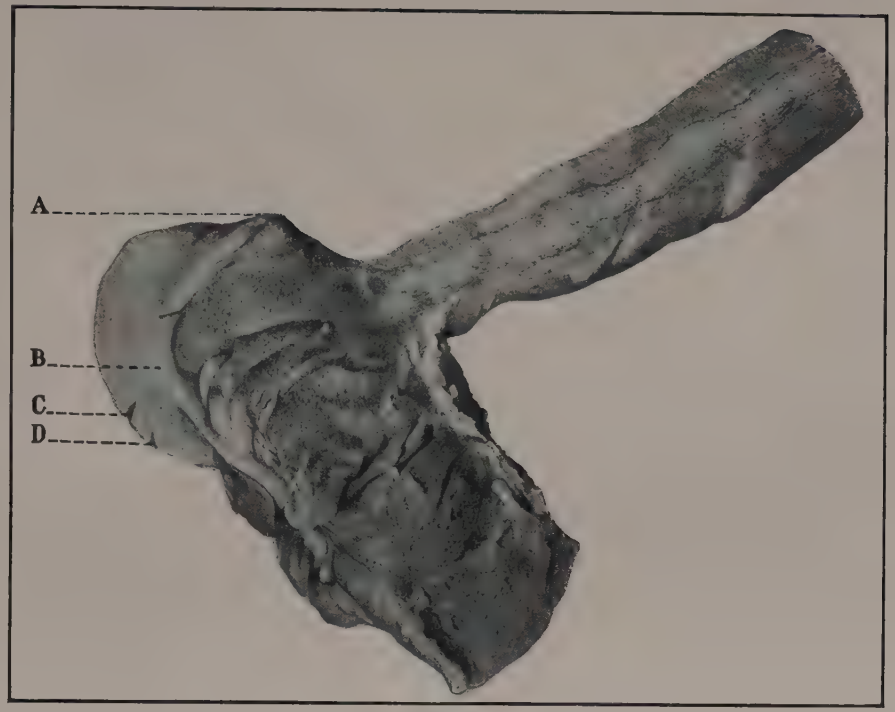


PLATE II.

PLATE III.

PROBLEMS IN ECONOMIC ENTOMOLOGY IN THE PHILIPPINES.[1]

By Charles S. Banks.
(*From the entomological section, Biological Laboratory, Bureau of Science.*)

What central Africa was to the geographical explorer two decades ago, the Philippine Islands are to the naturalist and especially the entomologist to-day—a vast region, the area of which is surmised to a greater or lesser extent, but the richness of which is, even yet, undreamed of.

In years gone by a few such adventurous spirits as Semper, Cuming, Worcester, Bournes, Whitehead, and some others made collections in entomology, botany, ornithology, general zoölogy, and conchology, and their material has been for the most part thoroughly classified and deposited, that which was not in some manner lost or destroyed, in the great museums of Europe and America.

But the question of biological research in so far as economic entomology is concerned has gained an impetus only during the brief years which have elapsed since sovereignty of this territory passed from Europe to America. I know of but one publication dealing with this important phase of biologic work in the Philippines previous to the beginning of this century, and that is a small pamphlet by Don Domingo Sanchez y Sanchez entitled "Memoria sobre un Insecto Enemigo del Cafeto," published in 1890, and treating of a species of *Xylotrechus* (*Clytus*) attacking coffee plants in the Province of Batangas.

Until the establishment of the civil régime under the United States Government, no formal work, as far as known, was done upon the locusts so common and so abundant in these Islands, and insects affecting cocoanuts trees, cacao, forest trees, timber, man, and domestic animals have only in very recent years received any degree of attention.

At the present time, it may be safely said that the two chief questions confronting the entomologist in these Islands are those with reference to locusts and mosquitoes.

[1] Read at the nineteenth annual meeting of the Association of Economic Entomologists, New York, N. Y., beginning December 27, 1906.

LOCUSTS.

(*Acridium manilense* Shiner.)

It must always be borne in mind that the topographical features of the Philippine Islands are such as favor to a great extent the propagation of the Philippine migratory locust. There are vast areas of waste land comprising both level and mountainous regions, and from all observations thus far made the insects repair, with a certain degree of regularity, to such regions, after having made depredations upon the small areas of cultivated land. It is certainly not possible that such vast hordes as at times appear in certain cultivated regions could gain their sole sustenance from tilled lands.

The so-called locust fungus has been used since 1902 in experiment against these insects, but, save for a very meager positive result in the laboratory, practically all of the trials made have resulted negatively. This may be due to one of two causes, either that the fungus used became contaminated and lost in the processes of transfer or to the fact that the locust found here is not susceptible to the attacks of the fungus.

During the past three years very accurate data have been secured with reference to the life history of these insects, with the important exception of their periods of disappearance from inhabited regions. Within a very few months it is hoped to establish an expedition which will have as its object the thorough exploration of waste mountainous regions for the purpose of further studying the locusts in their natural haunts.

No accurate estimate can be made at present of the damage caused annually by locusts, but from the very incomplete returns we know that it is very great, the crops suffering most severely being rice and sugar cane.

RICE INSECTS.

Aside from locusts, rice is seriously affected by three other insects, the rice army-worm (*Spodoptera maurita* Boisd.), the rice stem borer, a recently discovered and as yet unidentified species belonging to the Pyralidæ, and the tiañgao (*Leptocorisa acuta* Thunb.), an hemipterous insect which causes considerable damage by attacking rice in the "milk" and sucking the juices from the young heads.

The rice army worm, so-called because of the habit of the larvæ of traveling in companies, like *Heliophila unipuncta* Haw., of the United States, has caused considerable loss, especially in the Provinces of Pangasinan and Tarlac, in Luzon. The stem borer has but recently come to my notice, it having been found as a larva on a rice grown at the Government experiment station in Manila from seed brought from North Carolina. The egg being laid near or upon the ligula, the tiny larva bores into the stem in the upper joint and by the time it is full grown

it will have bored through several nodes and have found lodgment in the third joint from the top or near the ground. The adult of this insect has not been reared.

CORN AND SORGHUM INSECTS.

Both of these plants are attacked to some extent by the rice army worm, but corn has a special enemy in the form of the stalk borer (*Pyrausta vastatrix* Schultze, MS.). Sometimes as many as three or four of the larvæ are found in the same cornstalk. Plants so attacked seldom bear fruit.

Sorghum, with which cultural experiments are being carried on at the experiment station here, is affected when in bloom by a tiny, unidentified Cecidomyid, the female of which lays as many as twenty or thirty eggs in a single spikelet. Last year the seed production of the plants was lessened as much as 80 per cent by the ravages of this insect.

COCONUT INSECTS.

Being one of the chief industries in the Philippines, the cultivation of coconuts when menaced by insect attacks assumes a discouraging aspect. There are not many very serious pests found upon this very useful tree, but those that do attack it bring about the most sinister results. Its principal enemies are the rhinoceros beetle (*Oryctes rhinoceros* Linn.), the Asiatic palm weevil (*Rhyncophorus ferrugineus* Fabr.), and the transparent scale (*Aspidiotus destructor* Sign.).[2] It has been found that the only effectual means of contending with these pests is constant vigilance to prevent their entrance into a plantation and, when present, to rid the trees of them before they can do serious damage. Clean cultivation, together with moderation in the matter of removing dead leaves from coconut trees, has proved the most effective mode of procedure in this as well as other coconut-growing regions.

SUGAR-CANE INSECTS.

This staple Philippine product is exceptionally free from insect attacks other than that of locusts. One species of stalk borer (*Aphodius* sp.), a beetle, which, as larva and adult, gives occasional trouble in the Island of Negros, and a species of Aleurodid, are the only pests worth mention in this connection. Our greatest energy with reference to this plant will be used in the prevention of possible future importation of infected "seed" cane from regions such as Hawaii, where the sugar-cane leaf hopper (*Perkinsiella saccharicida* Kirk.) has done so much damage.

[2] For a full account of these insects see *Phil. Journ. Science* (1906) 1, 143–165 and 211–236.

CACAO INSECTS.

Until more attention is given to the cultivation of the cacao tree (*Theobroma cacao* Linn.) in these Islands, we need have no fear of any serious insect pests, although there are some few insects which claim our attention even now.

The longhorn borer of the cacao (? *Euclea* sp.) is by far the most serious pest with which we have to contend, while plant lice and termites of several species require, by reason of their persistent attacks, the closest vigilance upon the part of the owner of a cacao orchard.

TOBACCO INSECTS.

Tobacco grown under cover in the Cagayan Valley in northeastern Luzon suffered considerably two years ago from the attacks of plant lice (Aphididæ spp.), but these pests were successfully combated by the combined use of weak kerosene emulsion and fumigation with dried leaves, the latter operation, performed at night, being the more effectual of the two. During the past season no word has come from that region with reference to further attacks by these insects.

Stored tobacco, in the leaf, and the manufactured article in the shape of cigars and cigarettes, in the factories in Manila suffered to some extent in the early part of 1905 from the attack of the cigarette beetle (*Lasioderma serricorne* Fabr.), but greater care in preparation and handling, together with methods looking to the screening of rooms where the leaf was handled and the cigars and cigarettes were made and packed, seems to have effectually reduced this troublesome little pest; at least we hear no further complaint of its ravages.

In all parts of the Islands where tobacco has been seen growing the work of a small tree cricket (? *Paracœcanthus* sp.) has been noted on the leaves and seed capsules. The males of this insect cut circular holes in the leaves, over which they rest while stridulating, in this way apparently giving greater resonance to their notes. Individuals of both sexes, as well as the young, eat large holes in the nearly ripe seed capsules, causing a great loss of seeds. No measures have been tried with the view of ridding the plants of this pest, but its ravages must cause considerable damage to leaf to be used as wrapper.

TERMITES AND ANTS.

Like all tropical countries, the Philippines have their full mete of white ants and "just ants." The former, as is well known, are among the most destructive pests with which civilization is burdened in warm regions. They destroy everything vegetable with which they come in contact, excepting a few of the native Philippine woods such as molave (*Vitex littoralis* Decne.) and one or two others. Nothing is safe from their attacks wherever it may be placed. I know from an all too sad

personal experience their love of books, maps, furniture, clothing, and apparatus, while from others I have heard of their destroying phonograph boxes, gunstocks, trunks, school furniture, and houses.

The Insular Treasury suffered from these insects the inconvenience of the loss of some $1,500,000 worth of revenue stamps, stored in an iron vault encased in some 30 inches of cement on all sides, the termites having entered from the outside of the building, through cracks in the cement, caused by settling, and then through crevices between the iron plates of the vault.

One of the most useful preparations against the attacks of termites is found in the substance called "Carbolineum." It has been found that two coats of this substance applied to any woodwork liable to be attacked by termites effectually preserves it from damage for about two years.

Ants of many species are common throughout the Islands. The most troublesome species, however, is the little red ant (*Monomorium latinode* Mayr), which is certainly omnipresent in either the broadest or the most restricted sense of the word. They make their nests in every available place about houses and feed on all kinds of animal substances, even attacking leather sweatbands in hats, patent leather shoes, which they usually puncture somewhere on the front where the damage shows most, and as for entomological specimens, either dead or alive, which are sent through the mails or left upon tables in the laboratory they make short work of destroying them completely. A piece of white, starched cambric tacked over a window to modify the light was completely riddled in a few weeks' time by these little insects in search of the flies, beetles, and other forms which found a place between the cloth and the window panes.

Unless kerosene be placed in vessels of water in which the legs of tables stand, the ants will find some means of crossing the "moat" if they have to form a living bridge, as has been observed by me very frequently. Articles suspended from the highest ceiling are not isolated unless petroleum be placed on a wad of cotton around the string or wire of suspension. A favorite place of rendezvous for these ants is around a lighted lamp, when atmospheric conditions cause large numbers of other insects to fly into the house in the evening. They attack all kinds of insects and soon dismember and carry them off. All experiments in the breeding of insects must be done on tables isolated from their attacks, or otherwise eggs, larvæ, pupæ and adults would be destroyed over night.

Destruction of their ground nests results in the building of others by the individuals which escape. The only feasible method so far discovered to combat the pests has been the continued application of kerosene to vessels of water in which the legs of the furniture are placed. Sometimes a single spider web, the work of a moment, will furnish means of transit to these little marauders and the labors of weeks will be brought to naught.

INSECTS AFFECTING DOMESTIC ANIMALS.

Aside from fleas, in the case of dogs and cats, and a species of louse (Lipoptera=Mallophaga) of the carabao, our domestic animals are comparatively free from parasitic insects. True, the various species of horseflies (Tabanidæ) and *Stomoxys calcitrans* Linn., are rather abundant at certain seasons, but they are not as annoying to animals as similar species in the United States, and flies like the horn fly (*Haematobia serrata* Desv.), the horse bot (*Gastrophilus equi* Fabr.), and the ox warble (*Hypoderma lineata* Villers) are, so far, unobserved here.

MYIASIS AND HUMAN PARASITISM.

During my work here one or two very severe cases of human myiasis have come under my observation. In one case the flies were identified as *Lucilia dux* Esch.

The ordinary house insects, such as the bedbug (*Cimex lectularius* Linn.), the house fly (*Musca domestica* Linn.), (*Musca* spp.), the head louse (*Pediculus capitis* De Geer), the crab louse (*Phthirius inguinalis* Leach), and the flesh flies (*Sarcophaga* spp.) are all abundant, but the natives usually have their remedies for those which give them bodily discomfit, while they completely disregard flies of all kinds, even mosquitoes, as a necessary and therefore bearable evil.

MOSQUITOES.

No one single problem in economic entomology, in so far as its relation to human well-being is concerned, develops such large features as that of the limiting of mosquitoes.

Up to the present time there have been recorded from the Philippine Islands 83 species [3] belonging to this family.

Work on yellow fever and malaria in the United States and on the latter disease in India, Italy, Africa, and elsewhere has shown, more or less accurately, the species of mosquitoes which play a rôle in the transmission of these diseases. No work has as yet been done in the Philippines showing which of the 17 species belonging to *Anophelinæ* are the carriers of malaria. This field of research, which has been unexplored here because of pressure of other and routine work, will be entered into as soon as a way is seen whereby some of the ordinary routine can be given over to others, and it is not too much to suppose that some interesting developments will be had.

Filaria have been already demonstrated in at least one species of mosquito in the Philippines, namely, *Culex fatigans* Wied., but as this work is to be published at no late date, nothing further in regard to it will be included here.

[3] Banks: A list of Philippine Culicidæ, etc., *Phil. Journ. Sci.* (1906) **1**, 977 et seq.

Many data have already been gathered with reference to the life histories of Philippine mosquitoes, and a series of publications looking toward the eventual monographing of forms found here is part of my program for the near future.

When more is known in this regard, we can the more successfully plan and execute preventive campaigns against these insiduous foes of mankind.

USEFUL INSECTS.

SILKWORMS.

Of the work that has been done on useful insects, principal mention might be made of experiments looking to the introduction of silkworms into the Islands.

As far back as 1593 attempts were made by one of the early Spanish priests, Padre Antonio Sedeño, to introduce the silkworm into the Philippines, he having brought the mulberry and the "seed" here from China. Again, in 1780, Padre Manuel Galiana made a second endeavor but without success, save that plants from some of the original mulberry trees are still to be found in Manila and the Provinces of Tarlac and Batangas.

In spite of the fact that silk growers claim a temperature of more than 25° C. as injurious to the silkworms, our experiments both in the laboratory and in the field have proven that an excellent grade of silk can be obtained.

Our chief care will be as to the best method or keeping the eggs from the time of laying to hatching, but we hope to solve this by the use of a mild degree of cold in cold storage, facilities for which are now to be had in the chief towns of the Archipielago.

BEES.

Up to the present little attention has been given to bees in these Islands. There are at least three wild species which are found in considerable abundance throughout the Archipelago: *Megapis dorsata* Fabr., *M. zonata* Smith, and *Apis indica* Fabr., with *A. nigrocincta* Smith and *A. unicolor* Latr., which by some are considered mere varieties.

Of these, it is doubtful if *Megapis dorsata* Fabr., will ever submit to domestication. *Apis indica* Fabr., has already been kept successfully in hives and does fairly well, considering the fact that no scientific cultural methods have been followed.

There is no reason why American or Caucasian bees would do otherwise than well in the Philippines, although two attempts at importation on the part of a private individual have proven failures, owing to improper care of queens and brood in transit.

A rather inauspicious augury for the raising of bees here is the fact that the bee moth (*Galleria mellonella* Linn.) is very abundant and

troublesome. Of course methods of combating it other than those employed in America must be sought here, owing to the continued presence of summer with us.

FOREST INSECTS.

This field has been practically untouched thus far in the Philippine Islands. There is no doubt that with the further development of lumbering interests here, the beginnings of which have already been made, there will come the necessity for careful study of many insects in this connection.

Already we have reports of damage to lumber on the holdings of a company in Occidental Negros, and we expect that this feature of our entomological work here will grow in proportion as commercial work is carried on.

I have thus briefly outlined the chief problems that confront us in economic entomology. We are in a virgin field, we must hew our way, depending for guidance upon the work that others have done in other countries, yet there are features here so peculiar to the region that we must, as work goes on, devise other plans and work out other methods suitable to climate, conditions, and people.

The work here is peculiarly an unfolding work; we meet new conditions daily, and we must be able to cope with these conditions.

PHILIPPINE FIBERS AND FIBROUS SUBSTANCES: THEIR SUITABILITY FOR PAPER MAKING (PART II).[1]

By GEORGE F. RICHMOND.

(*From the Chemical Laboratory of the Bureau of Science.*)

In Part I of this paper, the waste fibrous materials which result from the isolation of the textile or cordage fibers taken from abacá, plantains, and maguey were discussed, they being included in the first division, namely, *textile papers,* according to the scheme as outlined under "Paper materials" on page 439.

Leaving out of consideration the second division, which includes *bast papers* made from the bast fibers of dicotylidonous plants—e. g., paper mulberry, ramie, jute, etc., which latter are not grown in the Islands in commercial quantities—the next important division from the standpoint of the distribution of raw materials is that of the *bamboo* and *grass* papers; two of these, namely, the perennial grasses *cogon* and *talâhib,* have already been considered. The paper-making qualities of bamboos, palm fibers, and Philippine pulp woods still remain for discussion; these will be taken up in the order named.

BAMBOOS.

The bamboos are giant members of *Gramineæ* (Grasses), the other individuals of which, while widely distributed, of great value, and very numerous, are for the most part insignificant as to bulk, height, and structural characteristics. The canes and bamboos are exceptions in that they form what may well be called forests and produce woods used in construction. The bamboos include about twenty genera and two hundred species and are distributed unevenly over the tropical zone.

Botanical description.—Tall, bushy grasses with woody stems or culms, for the most part growing in clumps. The bamboo stem, as is the case with all other grasses, consists of a more or less hollow culm with transverse, solid joints or nodes. Great variation exists among the various species with respect to the size of mature stems and the thickness of the shell walls.

This gigantic grass is remarkable for its rapid growth under favorable conditions of heat and moisture.[2]

[1] Continued from p. 462.

[2] Watt: *Dictionary Economic Products of India* (1885), 1, 374.

(1) "Much has been written as to the rate of growth of the shoot. It is probable that an average of three inches per day would not overstate the growth of the young shoots of the more important species. Until the branches have been fully developed the culm is not mature. This generally occupies a variable but considerable period, the shoot attaining its full height in from one to three months."

The question of making paper from bamboo is by no means a new one, but has been the subject of much study by paper-manufacturers in India and other bamboo-producing countries.[3]

(2) "Of all the fiber-yielding plants known to botanical science, there is not one so well calculated to meet the pressing requirements of the paper trade as 'bamboo,' both as regards facility and economy of production as well as the quality of the paper stock which can be manufactured therefrom; grown under favorable conditions of climate and soil there is no plant which will give so heavy a crop of available fiber to the acre, and no plant which requires so little care for its cultivation and continuous production."

For the reasons stated on page 434 and because of problems of a practical nature which were encountered at the time of Mr. Routledge's inquiries the question of utilizing bamboo for paper stock was abandoned. Later, about 1890, the manufacture of paper from elephant grass (*Ochlandra travancorica*), a species of Indian bamboo, was started at Travancore, British Burmah, but was discontinued.[4]

(3) "The material proved difficult of treatment. A very large quantity of caustic soda was required to reduce the fiber to stock, and an unusually large quantity of bleaching powder had to be employed to make white paper out of the yellow colored stock. Then, experiments had to be carried out to ascertain what aged culms gave the best results, no experience being obtainable from elsewhere on this point. The cost of erecting the works, moreover, far exceeded the estimates. The business was carried on for about five years and information on many points was recorded but then funds ran out, and just as there seemed some prospect of the concern paying, work had to be stopped for want of money.

This was unfortunate, for experts all agreed that for strength and durability, the paper made from the *Ochlandra* was superior to the best esparto, and for cotton mill wrappers and purposes for which strength is a desideratum, this material stands unrivaled."

In 1904 the late C. D. Ekman, one of the leading exponents of the sulphite pulp process and a European authority on pulp and paper manufacture, refers to bamboo pulp.[5]

He called attention to the extreme fitness of bamboo fiber for blending with sulphite wood pulp to improve the quality and to remove the woody appearance of the latter. The length of fiber, softness, and whiteness of bamboo pulp are equal to these same qualities in the best cotton pulp.

[3] Routledge: *Bamboo as a Paper Making Material*, E. & F. N. Spon, London (1875).

[4] T. F. Bourdillon: *Indian For.* (1899), **25**, 153.

[5] C. D. Ekman: *Wochenbl. f. Papier Fab.*, **35**, 461, 462.

"Bamboo," he says, "could not be transported to Europe at a profit but would have to be pulped where it grows. Every species of bamboo is not equally suited for pulp making. The pulp is generally difficult to bleach and requires a large proportion of bleaching powder. Some species can be bleached a good white with 15 per cent of bleach while others treated in the same way give a poor color with even 25 per cent of bleach. Only full-grown culms can be treated economically."

Still more recently R. W. Sindall,[6] a paper and pulp expert of London, was sent by the British Government to India to investigate the possibility of developing the paper industry in that country. He writes as follows:

(4) "In my opinion the bamboo of India may sometime supplant spruce wood in the manufacture of pulp for paper making. I have made lengthy experiments and have found that the bamboo is practical in the manufacture of pulp."

As is well known, bamboo has long been used to made paper in China—in fact, it is the chief material in use for this purpose in that country. The Chinese employ the native bamboo, which they split into lengths of from 1 to 1.3 meters each and then place in a vat or tank with alternate layers of lime; water is then run in to cover the stems and the whole left for three to four months; when the bamboo has become sufficiently rotted it is pounded in a mortar, mixed with water, and molded into square sheets of paper.

It was the firm belief of Mr. Routledge that only young shoots, collected before the plant had arrived at maturity and become hardened by a deposit of silicious matter, would be serviceable for paper making, and it was upon this supposition that the main objections and practical difficulties to the use of bamboo for paper stock were based. It was also found at the time that the removal of young and tender stems from the growing plants was disastrous to the parent stock to such an extent that entire bamboo forests would be endangered, and that the cost of transportation of the young, succulent shoots from the jungles to the mill site would prohibit their economic use. Kurz[7] reports that repeated cutting of too many bamboo shoots considerably weakens the stock, while the cutting of full grown culms does not injure the growth more than mowing does grass.

As the only practical attempt at the manufacture of paper from bamboo, namely, that from elephant grass in British Burmah, resulted in the report that this particular species is very resistant to chemical treatment, it was thought advisable to experiment with at least two different varieties of Philippine bamboo in order to determine their value as compared with other graminaceous fiber plants to which they are closely related and also with pulp woods, which, because of their dense, woody nature, they so much resemble and with which they should perhaps more properly be compared.

[6] *The Paper World and Wood Pulp News* (1906), **29**, No. 17.
[7] *Indian For.* (1876), **1**, 257.

PHILIPPINE BAMBOOS.

The two most important and widely distributed Philippine bamboos are the common, thick-walled variety (*Bambusa blumeana*), and the thin-walled dwarf bamboo, also known as *caña-boho* (*Bambusa lumampao*). The former is almost exclusively used for building purposes, because of its strength and durability; it is grown as a crop along the river bottoms of Pampanga Province and in many other regions; cuttings are set out in rows 2 to 3 feet apart and merchantable sizes are produced in from one to two years.

Dwarf bamboo is the variety in general use throughout the Islands for the manufacture of the *sauale, quisame,* and *amatong,* which are woven products used for lining or filling the walls, ceilings, floors, doors, and shutters of nipa houses. This bamboo is found almost entirely within the forested regions and forms one of the most damaging influences to forest growth, it being almost as undesirable as clearings. In parts of Bataan Province immense tracts of this plant are annually cut and rafted to the market. This species is never cultivated.

"*Caña-boho,* probably *Bambusa lumampao,* is a characteristic form on the Lamao forest reserve. The clumps are composed of 15 to 20 culms, 12 to 18 meters in height and set on an average of 3 to 4 meters apart; not infrequently these clumps grow so close together that it is difficult to wedge a way between."[8]

CHEMICAL COMPARISON WITH OTHER GRASSES.

The fibers of graminaceous plants exhibit a certain resemblance in form and appearance. Manifestly, papers made from these substances should possess very similar properties. The grass-like character of bamboo is further shown by the similarity of its chemical composition with that of other grasses; this will be understood by a study of the following table:

TABLE I.

Constituents.	Bamboo.[9]	Wheat straw.[9]	Rye straw.[9]	Structural bamboo.[10]	Dwarf bamboo.[10]
	Per cent.	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*
Cellulose	50.13	46.60	47.69	53.94	55.75
Fat and wax	.78	1.49	1.93	.96	1.03
Aqueous extract	10.56	8.07	9.05	4.98	4.69
Noncellulose or lignin	24.84	28.49	26.75	24.25	21.27
Water	8.56	9.85	11.38	12.40	11.20
Ash	5.13	5.50	3.20	3.47	6.03

[8] H. N. Whitford: The Vegetation of the Lamao Forest Reserve. *Phil. Journ. Science* (1906), 1, 386.

[9] Hugo Müller: *Pflanzenfaser,* Leipzig (1873).

[10] Analyses made by Mr. Mariano Vivencio of this laboratory. It is also advisable to compare the above analyses of bamboo with those of the perennial grasses, esparto and cogon, given on page 458 of *Phil. Journ. Science* (1906) 1.

PREPARATION OF PAPER CELLULOSE FROM BAMBOO.

The procedures employed for obtaining paper cellulose from esparto and the cereal straws are applicable to bamboo as well. Because of the great solvent action of alkaline solutions, comparatively little pains are necessary in the preparation of bamboo for the digestion process. First, there is no bark to be removed, as in the case of the dicotyledinous pulp woods; fresh, mature stems need simply to be chipped, or better, cut in suitable lengths and crushed by passing between heavy, fluted rollers.

The quantity of alkali required to produce a well-boiled pulp from mature stems of the above-mentioned species of bamboo we have found to be 15 to 20 per cent caustic soda, calculated upon the gross weight of the material digested, which concentration yields from 40 to 50 per cent of a light-brown fiber, which has a clean and soft appearance suitable for wrappings, news, and book papers.

This consumption of alkali is not greater than is frequently necessary in practice for cooking esparto grass,[11] and other graminaceous plants, such as the cereal straws, which are so largely employed in Europe for fine paper stock. These require from 10 to 15 per cent of caustic soda to yield 33 to 37 per cent of pure fiber.

On the other hand, the commercial pulp woods used in the production of soda fiber demand a much greater proportion of alkali for their complete resolution; the amount of caustic soda employed in practice, in making soda wood pulp can only be approximated. It is customary to add sufficient liquor of a known strength to cover the chips, and this volume depends of course upon the state of division of the wood, the thoroughness with which it is packed or tamped down, and the form of boiler employed. Griffin and Little give 700 gallons of liquor per cord of wood when rotary boilers are used, and a much larger volume in case stationary, upright digesters are employed. One thousand gallons of liquor, carrying 7½ per cent caustic soda (the average strength employed), would contain about 284 kilos (625 pounds) per one cord of chips, but the weight of a cord of pulp-wood chips is very indefinite. Its approximate weight may be deduced indirectly, by knowing the amount of pulp a cord of wood will yield and the average percentage yield of pulp from a given wood by the soda process.

454.5 kilos (1,000 pounds) of pulp is considered an average yield from one cord of poplar wood. The average percentage of yield of wood pulp by the soda method of treatment may be given as 40 per cent. Thus 454.5 kilos of pulp represent 1,136.3 kilos (2,500 pounds) of wood, and one cord of wood (1,136.3 kilos) consumes 284 kilos of caustic soda, or 25 per cent, calculated on the gross weight of the wood.

The above calculation demonstrates that mature bamboo is much more easily resolved into paper fiber than is the most generally used wood employed for the manufacture of paper pulp by the soda process.

[11] See footnote No. 5, page 437 of *Phil. Journ. Science* (1906) 1.

PRELIMINARY PREPARATION OF BAMBOO FOR DIGESTION EXPERIMENTS.

At first the outer, silicated rind and the nodes or joints of mature culms were digested separately, but it was found that the latter yielded to alkaline treatment with the formation of very little shive, but with a less cellulose content than when internodes alone were used. The yield of pulp on the nodes and rind, respectively, was 35 per cent, as compared with one of 42 per cent on internode wood alone, under the same conditions. This deficiency is fully accounted for by the larger amount of mineral matter deposited in the joints and on the exterior surfaces of the mature bamboo stems.

All experiments in this direction showed that in practice the joints or nodes, if well crushed, would offer no resistance to caustic soda liquors and that it would not be necessary or even advantageous to effect any preliminary sorting between the different portions of the stem, hence in the recorded experiments no separation was practiced. Bamboo pulp, similarly to straw and grass fibers, shows a tendency to roll up into little balls under slow motion, so that rotary digesters would probably prove unsuited to this raw material.

EXPERIMENTAL PART.

All of the digestion and bleaching experiments tabulated below were made on 454 gram lots (1 pound) of air-dried material. The bamboo chips or sticks were packed into an upright digester, variable quantities of caustic soda liquor, in all cases sufficient to cover the chips, were added, and the heating was done by direct flame.

TABLE II.

STRUCTURAL BAMBOO (*Bambusa blumeana*).

Conditions of digestion.	Experiments.					
	I.	II.	III.	IV.	V.	VI
Strength of liquor ---------per cent--	10	10	7½	7½	3½	6½
Amount of caustic soda calculated on the weight of the material digested ----------per cent--	22½	20	17½	15	20	12½
Time of boiling----------hours--	9	5	5	5	5	5
Pressures employed---atmospheres--	6	5–6	8	6–7	8	6–7
Yield of pulp:						
Unbleached----------per cent--	41.75	42	42.55	41	42.7	43.1
Bleached ----------do----	----------	40.2	40.6	----------	39.4	----------
Amount of bleaching powder consumed ----------per cent--	22.85	21.7	23.9	----------	24.8	----------
Loss of weight in bleaching---do----	----------	4.4	4.6	----------	7.9	----------
Color ----------	Yellow.	Cream.	----------	----------	Poor white.	----------

TABLD II—Continued.

DWARF BAMBOO (*Bambusa lumanpao*).

Conditions of digestion.	Experiments.					
	I.	II.	III.	IV.	V.	VI.
Strength of liquor ——per cent——	10	10	7½	7½	3½	6½
Amount of caustic soda calculated on the weight of the material digested ——per cent——	22½	20	17½	15	22½	12½
Time of boiling——hours——	5	5	10	5	5	10
Pressures employed——atmospheres——	8	5–6	6–7	6–7	5–6	6–7
Yield of pulp:						
Unbleached——per cent——	44.05	45.6	47.22	49.1	46.33	50.4
Bleached ——do——	41.4	42.6	———	43.7	———	———
Amount of bleaching powder consumed ——per cent——	9.9	13.3	———	16.1	———	———
Loss of weight in bleaching——do——	6.1	6.8	———	12	———	———
Color	Cream.	Light cream.	———	Good white.	———	———

The experiments outlined above bring out the following considerations:

First. Dwarf bamboo is superior to the structural variety both in yield of unbleached pulp and in consumption of bleaching agent.

Second. Caustic soda in the proportion of 10 to 20 per cent, calculated on the gross weight of the canes, is sufficient to produce a well-digested pulp.

Third. The duration of the digestions and the pressures and corresponding temperatures carried are considerably less than are employed in pulping the common, soft woods by this process, and compare very favorably with those used in practice for straw cellulose manufacture.

Fourth. The structural bamboo requires excessive quantities of bleach (20 to 25 per cent) to produce at best a poor white, while the dwarf variety, on the other hand, is bleached a good white with the equivalent amount of powder consumed by annual and perennial straws, namely, 10 to 20 per cent.

PALM FIBERS.

Several species of the other *Palmeæ*, including rattans, betel-nut palm (*Areca catechu*), nipa palm (*Nipa fructicans*), buri palm (*Corpha umbraculifera*), and coconut palm (*Cocos nucifera*), are found widely distributed throughout the Archipelago and contribute to the local demands of the people for food and fiber.

The *bejucos* or rattans, which occur so plentifully throughout forested regions, are used principally for the manufacture of furniture, and they are far too valuable to be otherwise primarily employed. The various pieces of furniture into which rattans so largely enter are constructed entirely of this material and dwarf bamboo, so that old or worn-out

articles of this class could be utilized at a paper mill without any preliminary cleaning or sorting.

Betel-nut palm is found both in the wild and cultivated state.[12]

"The spathes which cover the flowering axis may be used for paper making, as so also might the fibrous pericarp which is removed from the nuts. The spathes are largely used in India for packing and in the preparation of small articles for personal use."

Nipa palm is a well-known and valuable plant which for the most part is cultivated. As this plant is found only within the influence of salt water, near the seashore, and as considerable commerce in the leaves of this plant for thatching purposes is already established, the long leafstalks, which contain a strong structural fiber but which are at present discarded as worthless, are available in large quantities.

Coconut palm.—The commercial fiber of this plant, known as *coir*, is found in the husk or fibrous pericarp surrounding the nut.

"The fiber is much impaired by waiting for the nuts to arrive at maturity, consequently, for fibrous purposes, the latter are usually cut at about the tenth month. If cut earlier than this, the fiber is weak; if later, it becomes coarse and hard, requires a longer soaking, and is more difficult to manufacture." [13]

Walker [14] has shown that the percentage of husks from nuts too green to be used for copra is 70 per cent of the total weight, that this quantity is 51 per cent on the kind of nuts ordinarily employed for copra production and about 33 per cent on thoroughly ripe, brown ones.

There is no established commerce in *coir* or coconut fiber in the Philippines, but there is a large and growing industry in copra, and coconut oil production is steadily increasing. Practically all the husks encountered in the coconut districts are dry, brown, and unfit for *coir* cordage, so that at the present time they are only used for fuel or thrown away. That the amount of coconut husks annually consumed is considerable is evidenced from the statistics on copra exportations.

In 1905 approximately 60,000 tons of copra were exported. This represents over 400,000 tons of nuts, which in turn represents an approximately equivalent weight of husks. These data do not include the vast quantity of nuts husked for local consumption, nor the nuts and oil exported as such.

As copra and oil will probably always be the products of first value in this industry, the husks produced and now almost exclusively used for fuel will be of a very inferior grade and their unsefulness for purposes other than fuel will, on this account, be limited. However, coconut husks contain considerable fiber, and as they are now a rather worthless

[12] Watt: *Dictionary of Economic Products of India*, I, 298.

[13] *Spon's Encyclopædia*, I, 939.

[14] The coconut and its relation to the production of coconut oil. *Phil. Journ. Science* (1906), **1**, 68–73.

by-product of a large and rapidly growing industry, and as this fact assures their availability in almost unlimited quantities, they are worth considering from the standpoint of their applicability for paper or pulp manufacture.

Lengthy experimentation with coconut husks has shown that the fibers can not economically be separated from the cellular matter in which they are embedded, at least not by caustic alkalies. A treatment sufficiently drastic to remove this nonfibrous matter not only causes too great an expense in the chemicals involved but seriously attacks the fibers themselves; furthermore, this class of fiber is not amenable to bleaching processes.

For the production of pulp for purposes other than paper this material appears both cheap and admirable. As a substitute for wood pulp in the manufacture of various commodities such as roofing and felting materials, in which case a complete removal of the corky layers is not necessary or advisable and where bleaching is not required, the husks could be prepared by mechanical means alone or by mechanical means followed by a mild alkaline treatment. In the dry state in which the husks come to the consumer they are easily roughly cleaned to form a tow-like mass of fibers, which greatly resembles oakum, and which represents from 40 to 60 per cent of the gross weight of the husk, depending upon the quantity of corky matter still adhering to it.

In those countries where coir fiber is an article of commerce, the husks are first crushed between heavy, fluted rollers, then passed through the extractor, which consists essentially of a cylinder covered with steel teeth which tear the fiber from the husk, and then a subsequent winnowing removes the short fiber and dirt.

Buri palm.—This palm is second only to the coconut palm in the variety and usefulness of its products. The tree is never cultivated, but it grows luxuriantly in a wild state in many sections of the Islands. The Recoleto estate in southwestern Mindoro contains hundreds of thousands of individuals of this species. One of the principal uses of this palm is to furnish material from which mats and sugar sacks (*bayones*) are made. The leaf is the only part suitable for these purposes. The long leafstalk, which contains abundant structural fiber, is employed for making fine hats and coarse ropes and twine. Throughout Panay, where this palm is widely distributed, it furnishes practically all the cordage fiber in use. Good-looking rope is made by beating the fresh, green leafstalks until the fibers are partially separated, and then, after drying, these are twisted into cordage of various sizes.

Only *coconut husks,* which were taken to represent the class of fiber to be obtained from any palm fruit-pericarp, and *buri palm* rope fiber, which was considered to typify the class to be obtained from the leafstalks of all palms, were studied.

EXPERIMENT PART.

COCONUT FIBER.

Experiment I.—The fibrous tow, prepared by shredding dry husks by hand, was digested for three hours at 4 to 6 atmospheres pressure with an excess of 2 per cent caustic soda solution. A yield of 47.76 per cent was obtained.

Experiment II.—Uncleaned husks, cut up into fine pieces and treated as outlined in Experiment I, gave a yield of 26 per cent.

Experiment III.—Fibrous tow prepared as in Experiment I, digested during seven hours at 6 atmospheres pressure with lime and soda ash in quantities sufficient to form 20 per cent caustic soda, calculated on the weight of the material treated, produced a 49 per cent yield of well-pulped fiber containing some undissolved foreign matter.

BURI PALM ROPE.

Experiment I.—Old worn rope was cut up into small pieces and digested for six hours at 4 to 5 atmospheres pressure with a 2 per cent caustic soda solution. A yield of 30.1 per cent was obtained.

Experiment II.—New 1-inch rope of this fiber, purchased in the open market and subjected to the same conditions as in Experiment I, gave a yield of 37.3 per cent.

Palm fibers, as I have stated above, do not bleach readily, hence no quantitative bleach experiments were conducted with these pulps. Handmade sheets of unbleached paper made from palm fibers were found to be strong and fairly free from shive.

The local profusion of this family of plants and the vast quantities of available waste material resulting from the well-established copra, sugar sack, and nipa thatch industries makes it worthy of attention. The dimensions of palm and bamboo paper fibers are given in the tables of fiber measurements on page 461. Microphotographs of palm and bamboo fibers, seen longitudinally, are appended.

In a concluding number of this paper will be discussed the applicability of Philippine soft woods for paper pulp, both by the alkali and acid processes. The preparation of sulphite cellulose from the various raw materials previously described; a further discussion of the availability of those materials and the extent of the local deposits of sulphur, clays, and limestones; their chemical analyses with respect to their special fitness for paper manufacture and the suitability of waters from different sources for manufacturing and boiler purposes will also be included.

ILLUSTRATIONS.[15]

PLATE I.

FIG. 1. Structural bamboo (*Bambusa blumeana*).
2. Dwarf bamboo (*Bambusa lumampao*).

PLATE II.

FIG. 1. Coir fiber (*Cocos nucifera*).
2. Buri-palm fiber (*Corpha umbraculifera*).

[15] Photomicrographs by Martin. Fibers seen longitudinally.

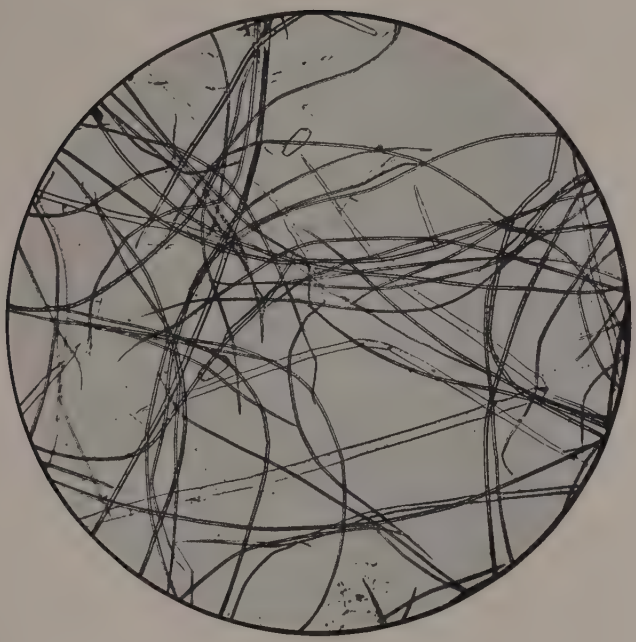


FIG. 1.

FIG. 2.

PLATE I.

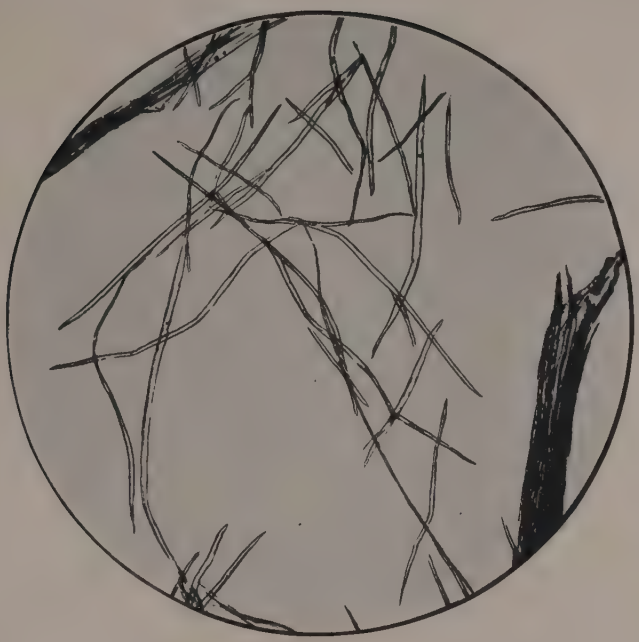


FIG 1.

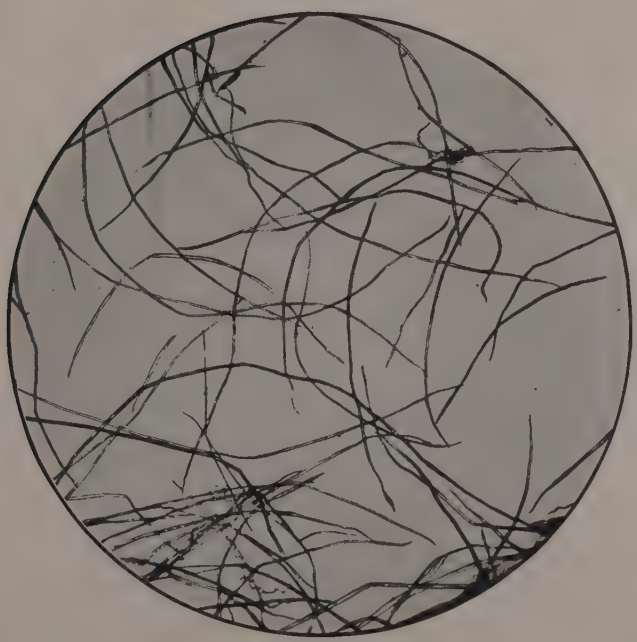


FIG. 2.

PLATE II.

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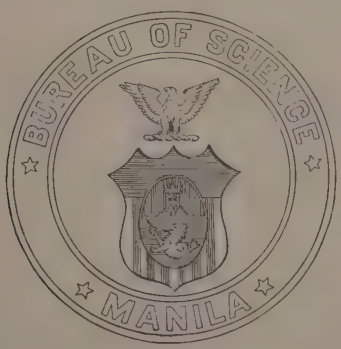

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ERRATA.

Page 143, line 6 from bottom, for *Rhinoceros* read *rhinoceros*.

Page 191, line 6 from bottom, for *Sindora wallichii* Benth. read *Sindora supa* Merr.

Page 195, line 18, for *grandifluus* read *grandiflorus*.

Page 199, line 25, for order read genus.

Page 200, line 34, exclude the *Dipterocarpus* tree, and substitute *Anisoptera vidaliana* Brandis (*Dipterocarpaceæ*).

Page 201, line 9, for *Dipterocarpus anisoptera vidaliana* read *Anisoptera vidaliana* Brandis (*Dipterocarpaceæ*).

Page 984, No. 28, line 5, for 996 read 995.

Page 984, No. 32, line 16 from bottom, for 995 read 996.

Page 991, line 2, for CHAMBERLAIN read CHAMBERLAINI.

For other errata see page 226.

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